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DEPARTMENT OF NATURAL RESOURCES

COPPER
IN CALIFORNIA

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DIVISION OF MINES
FERRY BUILDING, SAN FRANCISCO

STATE OF CALIFORNIA
EARL WARREN, Governor
DEPARTMENT OF NATURAL RESOURCES
WARREN T. HANNUM, Director

DIVISION OF MINES
FERRY BUILDING, SAN FRANCISCO
OLAF P. JENKINS, Chief

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COPPER
IN CALIFORNIA

(In Three Parts, Including Outline Geologic Map
Showing Locations of Copper Properties)

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GEOLOGICAL SURVEY, UNITED STATES DEPARTMENT OF THE INTERIOR
BUREAU OF MINES, UNITED STATES DEPARTMENT OF THE INTERIOR
DEPARTMENT OF MINING, STANFORD UNIVERSITY

LETTER OF TRANSMITTAL

To His Excellency, The Honorable Earl Warren
Governor of the State of California

Dear Sir: I have the honor to transmit herewith Bulletin 144, Copper in California, prepared under the direction of Olaf P. Jenkins, Chief of the Division of Mines. This volume is divided into three parts: PART 1, Detailed Reports on the Foothill Copper Belt; PART 2, Economics and Treatment of Ores; PART 3, Statewide Tabulation of Copper Properties to Accompany Economic Mineral Map of California No. 6. It consists of a large number of contributions by the United States Department of the Interior, Geological Survey and Bureau of Mines, based on strategic-mineral investigations conducted during the period of World War II. In addition the book contains a large amount of material summarizing pertinent data on all of the copper-belt deposits of the State. It is accompanied by a map pocket containing 52 detailed geologic maps and one mineral map of the State upon which are recorded many salient geologic facts concerning the copper resources of California.

Respectfully submitted,

Warren T. Hannum, Director
Department of Natural Resources

December 6, 1948

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PREFACE

Statewide reports covering the copper districts and copper industries in California are summarized in Bulletins 23 and 50, published in 1902 and 1908 respectively, by the California State Mining Bureau.

The present volume, Bulletin 144 of the State Division of Mines, tabulates all previous publications and records pertinent data on each copper property. It contains discussions on economics, marketing, and metallurgy of California copper, and a series of detailed geologic maps on the copper and copper-zinc deposits of the Sierran foothill belt.

During the period 1942-45 the United States Department of the Interior, Geological Survey and Bureau of Mines, carried on a strategic-mineral investigation of the copper and copper-zinc deposits of the Sierran foothill belt, because this area had returned to activity and gave promise of some contribution of strategic minerals to the war effort. Part One of this three-part volume is devoted to detailed geologic reports based on these studies and is accompanied by numerous geologic maps to be found in the map pocket. Part Two discusses the marketing and metallurgy of California's complex copper-bearing ores. Part Three discusses the general geology of the districts and economics of production; it provides an exhaustive tabulated list and bibliography covering all the copper occurrences reported in California (some 1,700 localities), the distribution of which together with other pertinent data are shown on the accompanying state map folded in the map pocket.

Though occurrences of copper minerals in mines and prospects of California are very widespread, the important commercial deposits have a limited geographic and geologic distribution. Ninety-two percent of California copper production through 1946 came from three areas. The largest part, 54 percent came from Shasta County; 26 percent from Plumas County; and 12 percent from the Sierran foothill belt.

A current project to investigate intensively the geology of the Shasta copper belt is being undertaken through joint sponsorship of the Federal Geological Survey and the State Division of Mines.

Similar geological studies in the third principal copper belt, which lies in Plumas County, have been under consideration but have not yet been started because there have been no copper mines operating in that area since shortly before World War II. At the time of that operation no geological survey was made either by the State or Federal Government.

It is hoped that Bulletin 144 may serve as a basis for further exploratory work on the copper-bearing deposits of California.

Olaf P. Jenkins
Chief, Division of Mines

San Francisco
December 6, 1948

PART ONE

DETAILED REPORTS ON THE FOOTHILL COPPER BELT

FOOTHILL COPPER-ZINC BELT OF THE SIERRA NEVADA, CALIFORNIA *

By George R. Heyl **

OUTLINE OF REPORT

ILLUSTRATIONS

ABSTRACT

Along the foothills of the western slope of the Sierra Nevada is a belt of copper and zinc mineralization, about 250 miles long, which includes portions of Butte, Yuba, Nevada, Placer, El Dorado, Amador, Calaveras, Tuolumne, Mariposa, Madera, and Fresno Counties, California. This mining district, originally opened during the Civil War years, had produced by the end of 1944 about 195,000,000 pounds of copper, 30,500,000 pounds of zinc, appreciable quantities of gold and silver, and a small amount of lead.

The rocks of the Foothill belt fall into two major groups—(1) the older, a complex of faulted and folded Paleozoic and Jurassic metavolcanic and metasedimentary rocks, which have been invaded by a variety of intrusions; and (2) the younger, a sequence of flat-lying or low-dipping volcanic and sedimentary deposits, of Tertiary and Quaternary age, that unconformably overlie the older series.

The copper and zinc deposits, developed within the older group of rocks, are for the most part lenticular sulphide bodies formed by replacement along zones of faulting, shearing, and crushing. In practically all instances they are associated with zones of sericitization, silicification, pyritization, or chloritization, developed by hydrothermal action superimposed on the metamorphic rocks. The deposits are characterized by abundant pyrite (less commonly pyrrhotite) associated with chalcopyrite, generally with appreciable quantities of sphalerite, and some gold and silver. On the basis of their primary mineral content they are classified into four types.

Structural control of ore deposition is evident in many deposits; particularly significant features are intersections or bifurcations of faults and shear zones, changes in strike or dip of fault surfaces, irregularities on contacts between rocks of markedly different competency, and the intersection of faults with such contacts.

Field evidence indicates the ore was introduced after the regional orogeny, the concomitant metamorphism, and the emplacement of the granodiorite intrusions, and the spatial distribution of the deposits suggests they are genetically related to the Sierra Nevada batholith.

It is believed that the Foothill belt offers opportunities for the discovery of additional ore reserves that can be profitably developed under favorable economic conditions.

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* Published by permission of the Director, Geological Survey, U. S. Department of the Interior. Manuscript submitted for publication April 27, 1948.

** Geologist, Geological Survey, U. S. Department of the Interior.

INTRODUCTION

Extending along the foothills of the western slope of the Sierra Nevada in California, from the vicinity of Feather River on the north to Kings River on the south, is a belt of copper and zinc mineralization developed in Jurassic and older metamorphic and igneous rocks. This Foothill belt (pl. 1) is about 250 miles long, and includes portions of Butte, Yuba, Nevada, Placer, El Dorado, Amador, Calaveras, Tuolumne, Mariposa, Madera, and Fresno Counties. It is limited on the west by the younger sedimentary rocks of the Sacramento and San Joaquin Valleys, and on the east by the Mother Lode district and its northern and southern extensions.

The Foothill copper-zinc belt ranges in altitude from 200 to 2,500 feet. By far the greater number of its mines are at elevations of less than 1,500 feet. The district is characterized by hot, dry summers; practically all of the precipitation falls during the mild winters. Throughout the year the region is readily accessible by road and railroad from the population centers of northern and central California.

The work summarized in this paper was a part of the strategic minerals program of the U. S. Geological Survey, carried on during 1942-45. Maps, sections, and brief descriptions of several mines and adjacent areas in the Foothill belt have already been published in preliminary form or placed in open files by this agency.[1] The results of the geologic studies in the copper-zinc belt are brought together and integrated in this report; in the following reports the geology of individual mines of the belt is described in greater detail. Information regarding many other deposits that were visited briefly during these investigations is incorporated in this report where possible.

It is a pleasure to acknowledge the able assistance given in the Foothill belt work by M. W. Cox, J. H. Eric, C. M. Gilbert, J. B. Hadley, G. L. Quick, M. H. Staatz, and D. G. Wyant, members of the U. S. Geological Survey. The writer is greatly indebted to Olaf P. Jenkins, Chief Geologist, California Division of Mines, and to R. S. Cannon, Jr., G. H. Espenshade, and M. H. Krieger of the U. S. Geological Survey, who have contributed valued criticism and important suggestions. Special acknowledgment and hearty thanks are due to N. L. Taliaferro, from whom the writer has benefited immeasurably through the many hours spent with him in the field, and in discussion of Sierran geologic problems.

HISTORY AND PRODUCTION

Though the Foothill belt during the nineteenth century was by far the most important copper-producing area in California, and is sometimes credited with being the site of the earliest mine, it was not within this district that copper ores were originally discovered or first mined. As early as 1840, within the limits of what is now the State of California, copper ores were noted, and were later mined on a small scale, in the Soledad district near Acton in northern Los Angeles County.[2] However,

[1] Strategic Minerals Investigations Preliminary Maps:
3-182, Quail Hill mine, Calaveras County, Calif. 1945.
3-183, North Keystone mine, Copperopolis, Calif. 1945.
3-184, American Eagle-Blue Moon area, Mariposa County, Calif. 1945.
Reports placed in open files:
Copper-zinc deposits of the Penn mine, Calaveras County, Calif. 1945.
Grayhouse area, Amador County, Calif. 1946.

[2] Browne, J. R., Mineral resources of the States and Territories west of the Rocky Mountains (for 1866), pp. 138-169, 1867.

this discovery, as well as other discoveries elsewhere in the state during the next two decades, seemed to have attracted little more than casual or local attention, and no important industry was established.

The discovery of ore within the Foothill belt in 1860 inaugurated a period of great activity in copper mining, and created an excitement which resulted in the exploitation during the next few years of a large number of important copper deposits. In November of that year the initial discovery was made by Hiram Hughes, who had recently returned to Calaveras County from the Comstock Lode. At what is now the Quail Hill mine in the southwestern part of Calaveras County, Hughes noted the gossan, which was rich in gold, and began working it for that metal. Soon afterwards he came upon the gossan of the Napoleon deposit, about 3 miles to the southeast. Finding less gold in it, but a mineral unknown to him, he sent some of the ore to San Francisco, where it was reported to contain 30 percent copper and to be worth $120 per ton. When this became known, local excitement broke out and soon spread to other parts of the Foothill belt, hundreds of claims being staked and recorded.[3]

The Reed lode at Copperopolis, on which are the Empire, Union, Keystone, and North Keystone mines, was discovered in June 1861. Shortly after, the Campo Seco, Lancha Plana, and Copper Hill claims were located in northwestern Calaveras County at the present site of the Penn mine. The Newton deposit in Amador County was discovered early in 1863. Some of the other mines that came into existence during the early sixties are the Spenceville, the Collier, La Victoria, the Green Mountain, the Lone Tree, and the Buchanan.

This copper boom continued through the Civil War years. Within 6 years after the initial discovery of copper ore in Calaveras County, smelters had been erected and were in use at the Union mine in Copperopolis, and adjacent to the Campo Seco, La Victoria, and Buchanan mines. J. R. Browne[4] estimates that by 1866 more than 100,000 tons of copper ore, valued at better than $5,000,000, had been taken out of the California mines, the Union mine at Copperopolis having produced more than half this amount and other Foothill belt mines having supplied most of the remainder.

However, by 1867, the industry had become greatly depressed, and many of the mines closed. This was in part a result of the fall in copper prices in 1866, and in part a consequence of the marked increase in mining and shipping costs that occurred during the following year.[5] In addition, in the case of some of the mines, the exhaustion of the high-grade ores from the oxidized and supergene enriched zones, and the lower tenor of the material available for mining at greater depth, undoubtedly contributed to the cessation of operations.

After the end of this early productive period, many of the mines remained inactive for several decades. However, a minor renascence in the belt occurred during the eighties, which was presaged in 1875 by the San Francisco Copper Company reopening the Spenceville mine, Nevada County. By 1884 this property had become the chief copper producer in California.[6] Activity at Campo Seco was renewed in 1883

[3] Browne, J. R., op. cit.
[4] Browne, J. R., op. cit.
[5] Browne, J. R., Mineral resources of the States and Territories west of the Rocky Mountains (for 1867), pp. 207-219, 1868.
[6] Kirchhoff, C. Jr., Copper: Mineral Resources U. S., 1883 and 1884, pp. 340-341, 1885.

Table 1. Recent production from principal mines in Foothill belt *

County and mine	Period	Ore (tons)	Copper (pounds)	Lead (pounds)	Zinc (pounds)	Gold (ounces)	Silver (ounces)
Amador							
Newton [1]	1943-46	41,214	[11]4,759,300	[11]2,000	----------	367	30,806
Butte							
Big Bend [2]	1943-45	28,817	[11]1,004,000	[11]118,000	[11]6,204,000	1,289	34,945
Calaveras							
Collier [3]	1942-44	5,613	[12]130,330	[12]83,161	[12]1,188,970	502	20,614
Keystone-Union [4]	1944-46	491,840	[12]1,323,791	----------	----------	53	3,802
North Keystone [5]	1942-45	225,549	[12]9,998,752	----------	----------	175	8,553
Penn [6]	1943-46	83,555	[11]3,321,300	[11]601,000	[11]12,293,700	5,827	199,005
Quail Hill [7]	1943-45	8,187	[13]480,773	[13]147,952	[13]2,064,071	2,607	41,859
El Dorado							
Lilyama [8]	1944-46	[14]4,520	[11]218,000	----------	----------	217	2,486
Madera							
Daulton [9]	1943-45	----------	[11]94,800	----------	----------	----------	----------
Mariposa							
Blue Moon [10]	1944-45	55,656	[12]406,038	[12]533,753	[12]13,687,920	3,446	208,965
Other Production [15]	1942-44	140	25,500	600	----------	26	128
Total	1942-46	945,091	21,762,584	1,486,466	35,438,661	14,509	552,163

1 Reopened January 1, 1943; shipments from July 1943 through 1946.
2 Shipments from May 1943 through 1945; mine closed December 28, 1945.
3 Shipments from 1942 to July 1944; mine closed May 15, 1944.
4 Production started late December 1943 through first half of 1946.
5 Production from October 1942 through first half of 1945.
6 Development work started October 1943; shipments 1944 through 1946.
7 Development work started 1942; shipments 1943 through late 1944 and short period in 1945.
8 Reopened 1943, production 1944 through 1946.
9 Precipitates from mine waters.
10 Development work started in 1943; mine closed November 15, 1945.
11 Pounds of recovered metal.
12 Metal contained in concentrates.
13 1943-44, contained metal; 1945, recovered metal.
14 Does not include 1946 tonnage of ore.
15 Approximate production from the Jesse Belle and Victory mines, Madera County, and Valley View mine, Placer County.
* Compiled from U. S. Bureau of Mines Minerals Yearbooks, 1942-46.

when H. D. Ranlett resumed operations at the Lancha Plana mine, which he later sold to the San Francisco Copper Company. In 1887 Ranlett reopened the Union mine at Copperopolis and the Newton mine near Jackson, and both were active during the succeeding several years.[7]

The turn of the century saw the beginning of an important period of copper production in the Foothill belt, which continued until after World War I when many of the mines again closed because of unfavorable economic conditions. Although the Keystone-Union mine at Copperopolis continued to operate until 1930, most of the other copper mines of the district ceased operating shortly after the end of the war, or in the early twenties.

The latest period of great activity in the belt began after the advent of World War II. In 1942, 1943, or 1944, the Daulton, Victory, and Jesse Belle mines in Madera County, the North Keystone, Quail Hill, Collier, and Penn mines in Calaveras County, the Newton mine in Amador County, the Lilyama mine in El Dorado County, and the Valley View mine in Placer County, all became significant producers of copper, or copper and zinc, in California. The Penn and Newton mines were still operating at the end of 1946. It should be noted that during World War II two new mines of consequence were developed by exploration and deepening of shallow gold prospects. These properties, primarily zinc producers, are the Blue Moon mine in Mariposa County and the Big Bend mine in Butte County. Recent production from the principal mines in the district is given in table 1.

Although it was not until recent years that the Foothill belt became important as a commercial source of zinc, it was in 1906 that zinc was first produced in California as a small byproduct of some of its copper ores.[8] Only small amounts of the metal were recovered in the years following 1906, largely because the techniques of mineral separation had not then been developed to the point where most of the ores of high zinc tenor from the district could be economically treated. That this is no longer true is shown by the fact that during 1942-46 approximately 35,000,000 pounds of zinc was produced from the mines of the belt, as against 22,000,000 pounds of copper.

The total production of the Foothill belt, from its inception in the early sixties to the end of 1946, can be placed at approximately 204,-500,000 pounds of copper and 50,400,000 pounds of zinc.[9] In addition, the district has produced an appreciable but undetermined amount of gold and silver, and a small amount of lead.

GENERAL GEOLOGY

The elongate area of mineralization known as the Foothill copper-zinc belt extends from Butte to Fresno Counties along the west flank of the Sierra Nevada batholith. The belt, which has a trend parallel to the regional strike, includes the foothill region lying between the Great Valley on the west, and the Mother Lode-northern Sierra gold province on the east (pl. 1).

[7] Aubury, L. E., Copper resources of California: California Min. Bur. Bull. 50, pp. 221-245, 1908.

[8] Hill, J. M., Historical summary of gold, silver, copper, lead, and zinc produced in California, 1848 to 1926: U. S. Bur. Mines Econ. Paper 3, p. 2, 1929.

[9] These figures have been based in part on those published in U. S. Bureau of Mines Economic Paper 3 and Minerals Yearbook, and in part on data obtained from the files of the U. S. Bureau of Mines, made available through the courtesy of C. W. Merrill and A. L. Ransome.

The rocks of the Foothill belt fall into two major groups—the older, a complex of faulted and folded Paleozoic and Jurassic metavolcanic and metasedimentary rocks, which have been invaded by a variety of intrusions; and the younger, a sequence of flat-lying or low-dipping volcanic and sedimentary deposits of Tertiary and Quaternary age that unconformably overlie the older series. The copper and zinc ore bodies are part of, and are developed within, the older group of rocks.

The Paleozoic and Jurassic strata within the copper-zinc belt have been divided by the U. S. Geological Survey into three units—the Calaveras, the Monte de Oro, and the Mariposa.[10] The oldest of these units is the Calaveras formation, generally considered to be Carboniferous in age; however, Knopf[11] states it may also include Triassic rocks as well as Paleozoic rocks older than the Carboniferous, and Taliaferro[12] believes it may embrace pre-Carboniferous strata as well as Carboniferous, and may also include Permian rocks. In the Taylorsville region,[13] the Colfax area,[14] and the Alleghany district,[15] all of which lie eastward and higher in the Sierra Nevada than the Foothill region, the Calaveras has been subdivided into several component units, but none of these units has yet been delineated in the copper-zinc belt. Gray chert, blue-gray recrystallized limestone, and marble are characteristic of the Calaveras, but within the Foothill belt it also includes gray clay slate and phyllite, green schists derived from volcanic rocks, conglomerate, sandstone, quartzite, and red chert. Fossils are known to occur only in the limestones, and are generally sparse and poorly preserved.

The relationship between the Monte de Oro and the Mariposa formations is somewhat uncertain, but the available fossil evidence points to a Middle Jurassic age for the Monte de Oro formation, and an Upper Jurassic age for the Mariposa slate.[16] The Monte de Oro formation, occurring in Butte County northeast of Oroville, consists of dark carbonaceous clay slate, with some conglomerate and sandstone; it contains a meager and poorly preserved fauna, but an abundant flora.

Although the Mariposa slate is predominantly dark blue-gray to black clay slate, weathering pale green or olive brown, it also includes fine-grained, light-colored siltstone, sandstone, graywacke, numerous conglomerate lenses, and, in places, volcanics. Fossils are not abundant,

[10] Lindgren, W., and Turner, H. W., U. S. Geol. Survey Geol. Atlas, Placerville folio (no. 3), 1894.
Lindgren, W., U. S. Geol. Survey Geol. Atlas, Sacramento folio (no. 5), 1894.
Turner, H. W., U. S. Geol. Survey Geol. Atlas, Jackson folio (no. 11), 1895.
Lindgren, W., and Turner, H. W., U. S. Geol. Survey Geol. Atlas, Smartsville folio (no. 18), 1895.
Turner, H. W., and Ransome, F. L., U. S. Geol. Survey Geol. Atlas, Sonora folio (no. 41), 1897.
Turner, H. W., U. S. Geol. Survey Geol. Atlas, Bidwell Bar folio (no. 43), 1898.
Turner, H. W., Further contributions to the geology of the Sierra Nevada: U. S. Geol. Survey 17th Ann. Rept., pt. 1, pp. 548-549, 1896.
Becker, G. F., Notes on the stratigraphy of California: U. S. Geol. Survey Bull. 19, pp. 18-23, 1885.
Turner, H. W., Some recent contributions to the geology of California: Am. Geologist, vol. 11, pp. 307-324, 425-426, 1893.

[11] Knopf, A., The Mother Lode system of California: U. S. Geological Survey Prof. Paper 157, p. 10, 1929.

[12] Taliaferro, N. L., Manganese deposits of the Sierra Nevada, their genesis and metamorphism: California Div. Mines Bull. 125, p. 280, 1943.

[13] Diller, J. S., Geology of the Taylorsville region, California: U. S. Geol. Survey Bull. 353, 1908.

[14] Lindgren, W., U. S. Geol. Survey Geol. Atlas, Colfax folio (no. 66), 1900.

[15] Ferguson, H. G., and Gannett, R. W., Gold quartz veins of the Alleghany district, California: U. S. Geol. Survey Prof. Paper 172, 1942.

[16] Taliaferro, N. L., Geologic history and correlation of the Jurassic of southwestern Oregon and California: Geol. Soc. America Bull., vol. 53, pp. 90-92, 107-108, 1942.

but occur at widely spaced localities; species of *Ammonites*, *Belemnites*, and *Buchia* (*Aucella*) are the most common. In 1910 J. P. Smith [17] suggested that the upper portion of the Mariposa slate, characterized by *Perisphinctes colfaxi*, be designated as the Colfax formation, thereby restricting the term Mariposa to the lower portion of the original unit; in general, this suggestion has not been followed.

N. L. Taliaferro [18] has shown that a thick section of volcanic and sedimentary rocks underlies the Mariposa slate in the foothills of the Sierra Nevada west of the Mother Lode. This sequence, designated the Amador group, varies in thickness from less than 5,000 to more than 15,000 feet. Conglomerates at the base of the Amador group carry pebbles and boulders of the underlying Paleozoic rocks. In some places, the top of the Amador group is marked by an unconformity; in others, the pyroclastics of the upper part of the Amador grade upward through fine tuff into typical Mariposa slate.

At the type section of the Amador group in the canyon of the Cosumnes River westward from Huse Bridge on the Mother Lode, the sequence is 7,000 to 8,000 feet thick; it has been divided by Taliaferro [19] into the Cosumnes formation and the Logtown Ridge volcanics, but these units have not been identified in the areas described in the succeeding chapters. The basal Cosumnes consists of alternating conglomerate and sandstone containing abundant debris of the underlying Calaveras formation; these beds pass upward into sheared arkosic sandstone and dark clay slate, which in turn grade upward into thin-bedded tuffs and fine-grained sediments. In the upper portion of the Cosumnes, very poorly preserved ammonites are present. The Logtown Ridge volcanics unit is made up largely of tuffs, fine to coarse augite andesite agglomerates, and flows, including pillow lavas. In the areas surrounding the mines described in succeeding chapters of this report, units of dominantly volcanic rocks are tentatively identified as belonging to the Amador group; regional studies would be needed to determine the relations between the rocks of the various mine areas. In the vicinity of the Newton copper mine several new formations, tentatively assigned to the Amador group, are described.

In Upper Jurassic time, after the deposition of the Mariposa sediments, the Foothill belt, along with the entire Sierran region, was raised above sea level, and the strata were strongly compressed, folded, faulted, and dynamically metamorphosed. This period of major deformation, known as the Nevadan revolution, marks the end of marine sedimentation in the Sierran province, and the establishment of the ancestral Sierra Nevada. There is some difference of opinion regarding the precise dating of the orogeny, Crickmay [20] placing it at the end of the Jurassic period,

[17] Smith, J. P., The geologic record of California: Jour. Geology, vol. 18, charts opposite pp. 217, 221, 1910.

[18] Taliaferro, N. L., Stratigraphy of the bedrock complex of the Sierra Nevada of California: Geol. Soc. America Bull., vol. 43, pp. 233-234, 1932.

Taliaferro, N. L., Bedrock complex of the Sierra Nevada, west of the southern end of the Mother Lode: Geol. Soc. America Bull., vol. 44, pp. 149-150, 1933.

Taliaferro, N. L., Geologic history and correlation of the Jurassic of southwestern Oregon and California: Geol. Soc. America Bull., vol. 53, pp. 71-112, 1942.

[19] Taliaferro, N. L., Manganese deposits of the Sierra Nevada, their genesis and metamorphism: California Div. Mines Bull. 125, pp. 282-284, 1943.

[20] Crickmay, C. H., Jurassic history of North America: its bearing on the development of continental structure: Am. Philosophical Soc. Proc., vol. 31, p. 64, 1931.

Hinds[21] stating that it occurred sometime between Upper Lias or Ludwigian time and the early Cretaceous (Paskenta), and Taliaferro[22] maintaining it took place immediately or very shortly after lower Kimmeridgian time and prior to the Portlandian and Tithonian stages of the Jurassic.

The intrusive rocks of the Foothill belt present a variety of types. Some of them antedate the Nevadan revolution, and are deformed and metamorphosed along with the rocks they intrude. To this group belong the hypabyssal equivalents of volcanic rocks of the Amador group, such as quartz porphyry, feldspar porphyry, and augite andesite porphyry. Likewise, peridotite and dunite, now largely serpentinized, and related gabbro and pyroxenite were injected as sills, intrusive sheets, and satellitic dikes prior to the regional folding.[23] It is interesting to note, however, that Knopf[24] believes the intrusion of peridotite in the neighboring Mother Lode district was subsequent to the close folding of the strata.

Plutonic rocks in the copper-zinc belt include granodiorite, and genetically related granite, quartz diorite, diorite, and gabbro.

There is strong evidence that the granodiorite core or pluton of the Sierra Nevada was emplaced after the deformation that produced the major folds and faults of the mountain range. In some places, as west and southwest of Mariposa, folds in Jurassic strata strike into and are interrupted by a major tonguelike extension of the main batholith, these folds continuing with the same trend on the opposite side of the intrusive mass.[25] Similarly, MacDonald[26] has found that in Fresno County, plutonic intrusions, including granite, quartz diorite, diorite, and grabbo, sharply truncate folds in the metamorphic rocks that they have invaded.

In other places, as in the vicinity of Placerville, and in Amador County immediately east of the Mother Lode, the granodiorite magma during emplacement was evidently guided by zones of structural weakness parallel to the regional trend of folding and cleavage. Cloos[27] has found that where the Mother Lode fault zone meets the Sierra Nevada batholith south of Mariposa, this fault structure is not continued within the granodiorite, and breccia, gouge, and displacements of the usual order of magnitude are absent. The major structural features of the province apparently were delineated before the emplacement of the batholith.

The pattern of outcrop of the Sierra Nevada pluton (pl. 1), and its internal structure as delineated by Cloos,[28] indicate that erosion has cut more deeply into its southern part than elsewhere, either because of greater uplift of the Sierra Nevada massif there, or because the southern portion of the batholith was emplaced higher in the crust. The main batholith has a northward plunge, and the core of the pluton southward from

[21] Hinds, N. E. A., Mesozoic and Cenozoic eruptive rocks of the southern Klamath Mountains, California: Univ. California, Dept. Geol. Sci. Bull., vol. 23, p. 335, 1935.

[22] Taliaferro, N. L., Geologic history and correlation of the Jurassic of southwestern Oregon and California: Geol. Soc. America Bull., vol. 53, pp. 103, 107, 1942.

[23] Taliaferro, N. L., idem., pp. 94-95.

[24] Knopf, A., op. cit., p. 14.

[25] Taliaferro, N. L., personal communication.

[26] MacDonald, G. A., Geology of the western Sierra Nevada between the Kings and San Joaquin Rivers, California: Univ. California, Dept. Geol. Sci. Bull., vol. 26, p. 258, 1941.

[27] Cloos, E., Mother Lode and Sierra Nevada batholith: Jour. Geology, vol. 43, p. 243, 1935.

[28] Cloos, E., Sierra Nevada batholiths and the Mother Lode zone: Geol. Soc. America Bull., vol. 44, pp. 79-80, 1932.

Cloos, E., Mother Lode and Sierra Nevada batholith: Jour. Geology, vol. 43, pp. 225-249, 1935.

El Dorado County has been reduced by erosion to the embatholithic [29] stage of Emmons.[30] The remainder of the west slope of the Sierra Nevada, including most of the Foothill belt from Mariposa to Butte Counties, and also the group of stocks and cupolas that probably mark a second batholith in the northwest part of the province, has reached the epibatholithic [31] stage of erosion, for it comprehends wide areas of the invaded country rock.

Throughout most of the Foothill belt, the regional metamorphism developed by the stresses of mountain building at the time of the Nevadan revolution is of the type characteristic of the epizone, and generally has resulted in the formation of slate, phyllite, quartzite, and greenstone and green schist containing abundant chlorite, epidote, or pale-green amphibole. Toward the southern end of the belt, however, where erosion has possibly bitten more deeply into the Sierra Nevada massif, metamorphic rocks of higher grade, such as mica schist and garnet schist, are widespread.

In the vicinity of the larger granitoid intrusions of the district, strong thermal metamorphism has developed aureoles of hornfels and contact schists; near such bodies andalusite (or chiastolite) is a common product in argillaceous rocks, hornblende in intermediate to mafic volcanics, and tactite in calcareous beds.

After the Nevadan revolution and the emplacement of granodiorite and related intrusions, the history of the Foothill belt, along with the remainder of the Sierra Nevada, is centered on the erosion of the raised mountain block. Concomitant with this erosion, which has finally cut so deeply into the range as to expose its structural roots, has been the deposition of a large amount of fluviatile and volcanic debris as a mantle of nearly flat-lying beds truncating the older structure. Though the Sierra Nevada massif was repeatedly uplifted and tilted westward during Tertiary and Quaternary time, the earlier-formed, complex structure of the range was little affected by these movements, except for broad regional warping, and normal faulting affording local adjustment.

ECONOMIC GEOLOGY

Ore Deposits

The copper and zinc deposits of the Foothill belt are, for the most part, lenticular sulphide bodies developed by replacement along zones of faulting, shearing, and crushing. Included within the belt, however, are irregular, lenticular quartz veins containing pyrite, chalcopyrite, and other sulphides. Many of these veins likewise have formed by replacement along fault and shear zones, though at some localities, or locally within some deposits, the filling of open fissures has apparently been important. In addition to these types a few sulphide deposits, not specifically typical of the Foothill belt though occurring within it, are developed at contacts of granodiorite intrusions, and their mineral association and other features point to a pyrometasomatic origin; examples are the Lilyama and the Pioneer deposits northwest of Coloma, El Dorado County.

[29] The embatholithic stage of erosion of a batholith is that where erosion has penetrated so deeply that the areas of intruding rocks are nearly equal to areas of the invaded rock.

[30] Emmons, W. H., Ore deposits of the western States (Lindren volume), pp. 345-349, Am. Inst. Min. Met. Eng., 1933.

[31] The epibatholithic stage of erosion of a batholith is that where erosion has gone only deeply enough to expose small parts of its barren core; metalliferous deposits are to be expected in and around the outer rim of the intrusive.

The typical Foothill belt sulphide deposits are characterized by abundant pyrite (less commonly pyrrhotite) associated with chalcopyrite, generally with appreciable quantities of sphalerite, and some gold and silver. In many cases, relatively small amounts of galena, tetrahedrite, and bornite are also common. On the basis of their primary mineral content, these Foothill belt ore bodies fall into four major types, which are summarized as follows:

(1) Deposits made up of sphalerite, chalcopyrite, and pyrite, generally with small amounts of galena and appreciable quantities of gold and silver. Examples: Big Bend mine, Butte County; Penn mine and Quail Hill mine, Calaveras County; Blue Moon mine, Mariposa County.

(2) Deposits consisting mainly of pyrrhotite and chalcopyrite, with or without pyrite and sphalerite, and generally with some gold and silver. Examples: Green Mountain mine, Mariposa County; Buchanan mine and Daulton mine, Madera County; Fresno copper mine, Fresno County.

(3) Deposits of pyrite and chalcopyrite, with practically no gold or silver, and with zinc minerals being absent or virtually so. Examples: Newton mine, Amador County; North Keystone mine and Keystone-Union mine, Calaveras County.

(4) Deposits composed of chalcopyrite, pyrite, and quartz, with or without sphalerite and pyrrhotite, and generally with some gold and silver. Examples: Eldorado copper mine, El Dorado County; La Victoria mine, Mariposa County; Jesse Belle mine, Madera County.

Besides those included in the above classification, other minerals of the Foothill belt include a variety of species, most of which are but sparsely present. Bornite occurs in some of the massive ore at the Penn mine and at the North Keystone mine; it was also observed in quartz-calcite veins and veinlets cutting the sulphide bodies in the Big Bend mine and in the Penn mine. Tetrahedrite has been observed at the Blue Moon mine, La Victoria mine, Big Bend mine, and at the Penn mine and its northern extension, the Grayhouse prospect. Cobaltite occurs as striated cubes in the Jesse Belle mine, and cubanite (chalmersite) is reported by Tolman[32] at the nearby Daulton mine. A small amount of visible native gold was present in white quartz-calcite veinlets at the footwall of the large ore body on the 1,100 level of the Penn mine. The ore produced from the Quail Hill mine during its 1943-45 period of operation had an average gold content of 0.318 of an ounce per ton, considerably higher than the gold content of ore from other Foothill mines. Lang[33] states that arsenopyrite was found in the Great Northern mine, Mariposa County, and stibnite in the Irish Hill mine, Amador County. Small flakes of ilmenite are locally abundant within the ore bodies of the North Keystone mine, and Knopf[34] reports the presence of sphene (titanite) and rutile, as well as a few crystals of andalusite, in the "ore rock" of the Copperopolis mines.

Magnetite is finely disseminated locally within the mineralized zones at the Penn mine and the Collier mine, Calaveras County, and this mineral is particularly abundant as disseminations and as veinlets in the footwall of the North Keystone ore bodies. Hematite and hematitic

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[32] Tolman, C. F., The Foothill copper belt of California in Copper Resources of the World, p. 249, Washington, 16th Internat. Geol. Cong., 1935.

[33] Lang, H., The copper belt of California: Eng. and Min. Jour., vol. 84, pp. 909-913, 963-966, 1006-1010, 1907.

[34] Knopf, A., Notes on the Foothill copper belt of the Sierra Nevada: Univ. California. Dept. Geol. Sci. Bull., vol. 4, pp. 411-423, 1906.

jasper occur within the wallrock adjacent to and on the strike extensions of ore bodies at the Penn, North Keystone, Collier, and Newton mines.

Gangue minerals, in general, are not abundant in the Foothill copper-zinc deposits. Milky quartz is the most common and widespread, and was observed in practically all the mines. White calcite is present in several of the deposits as veinlets in or adjacent to the ore bodies. Green chlorite is a minor gangue mineral, occurring not uncommonly as drusy masses in quartz veins within and adjacent to the sulphide bodies. Epidote, as large crystals or as small radiating groups, was seen in occasional vugs in the North Keystone ore. Knopf[35] reports chalcedony from the Copperopolis mines, and Cox[36] observed feldspar, biotite, muscovite, a small amount of epidote, and some graphite in the gangue at the Jesse Belle mine. However, the most characteristic gangue mineral of the belt as a whole is barite. It is an important constituent in the gangue at the Big Bend, Penn, Quail Hill, Collier, and Blue Moon mines, where it occurs intimately mixed with the sulphides, or, less commonly as at the Penn mine, as large bodies, lying adjacent to ore, that retain in places the schistose structure of the replaced country rock. Barite is present in lesser amounts in many of the other mines of the belt, including the Pine Hill mine in Nevada County studied by Lindgren.[37]

The ores from most of the mines are similar in appearance. They may be banded, showing the relict structure of replaced schist, or they may be massive. Most commonly they are intimate, fine-grained mixtures of sulphides, mainly pyrite (or pyrrhotite) and chalcopyrite, with or without sphalerite.

In ores from some of the mines, as the Blue Moon and the Penn, there are suggestions of crystalloblastic textures, such as augen-shaped grains, pressure shadows developed around pyrite crystals, and strain shadows. These textures indicate that some deformation occurred, at least locally, after the sulphides were formed, and suggests that a renewal or continuation of shearing took place during or after ore deposition. Field evidence corroborates this conclusion, for at places in the Penn and North Keystone mines ore is strongly slickensided, and faults were observed to displace ore a fraction of an inch to as much as 20 feet. At the Blue Moon mine a fault breccia containing fragments of ore forms the hanging wall of the main ore shoot, and drag folds in schistosity indicate reverse movement in this fault zone.

Most of the sulphide deposits of the Foothill belt are located within, or along contacts of, zones of hydrothermal alteration. Sericitization and silicification, generally accompanied by a certain amount of pyritization, are the commonest types of alteration. At Copperopolis, however, intense chloritization has been the dominant alteration process, with sericitization being evident only locally within the mineralized zone.

These alteration zones characteristically trend with the strike and dip, though in detail their contacts may cut across bedding, schistosity, and cleavage. They may appear as elongate lenses of hydrothermally altered rock, as belts made up of a series of such lenses, or even as a composite grouping of several such belts. In size they range from areas measuring a few feet or tens of feet in length and width, to some lenses

[35] Knopf, A., idem.
[36] Cox, M. W., personal communication.
[37] Lindgren, W., The gold deposit at Pine Hill, California: Am. Jour. Sci., 3d ser., vol. 44, pp. 92-96, 1892.

extending hundreds of feet in length, with widths as great as 250 feet. The belt of alteration at Copperopolis is approximately 9,000 feet long, while the composite group of alteration zones at the Penn mine and Grayhouse areas extends along the strike for more than 11,000 feet, its northern end being concealed by flat-lying Tertiary sediments. The alteration zones are known to continue down dip, without lessening of intensity, to the greatest depths of mining.

Where sericitization and silicification occur in the same alteration zone, sericitization appears to have begun earlier, and silicification to have continued later; pyritization, if also present, is generally the latest of the three, and, as a rule, it overlaps into the ore-forming period. At the Quail Hill mine the formation of a claylike mineral has also been an important alteration process in the mineralized zone, but its relation to the other wallrock alteration and the precise character of the mineral cannot be determined without extensive microscopic and chemical studies.

The copper and zinc ore bodies of the Foothill belt are lenses, lenticular veins, or somewhat irregular pod-shaped bodies. They show a wide range in size. A small one in the Quail Hill mine has a pitch length of 14 feet, and its roughly circular cross-section has a maximum diameter of 7 feet. Among the larger ones observed in the district are some at the Penn mine, where two ore bodies, mined along pitch lengths of about 1,000 feet each, have breadths, respectively, of 300 and 250 feet, and maximum widths of 22 and 31 feet. Others at this mine and at the Copperopolis mines approach these bodies in size, but many of the ore bodies mined in the Foothill belt have been considerably smaller than these largest ones.

Most of the ore bodies lie parallel to the foliation in the country rock, though in detail the boundaries of ore may crosscut schistosity or cleavage. They are, therefore, characteristically steeply dipping sulphide bodies, and in almost all cases they have their greatest elongation either parallel to the dip or pitching at a high angle in the plane of foliation. Some ore, however, has formed along low-angle faults or shear zones, as at La Victoria mine and at places in the Penn mine; these bodies, along with the irregularly shaped bodies of the Lilyama and Pioneer mines, form exceptions to this generalization.

Structural Controls

With the exception of the typical pyrometasomatic deposits of the Lilyama and Pioneer mines in El Dorado County, where the presence of limestone adjacent to a granodiorite stock offered a favorable physiochemical environment for ore deposition, the sulphide deposits of the Foothill belt generally are developed along faults or shear zones, where crushing and brecciation have been intense. Therefore, contacts between rocks of markedly different competency, faults and fissures within or subsidiary to regional fault zones, and the overturned, sheared and stretched limbs of major folds provide particularly favorable structural environments for the development of such tectonic phenomena. Within such areas, major clues in the search for ore may be obtained by working out the fault systems present by paying especial attention to the ground where faults intersect or bifurcate, by studying the detailed configuration of fault surfaces, and by mapping or otherwise delineating contacts between lithologic units.

Structural control of ore deposition is evident in many of the deposits. At the Penn mine ore bodies are developed at intersections of low-angle faults with high-angle faults or at lithologic contacts. The North Keystone deposit is a series of ore bodies formed on the hanging-wall side of a major fault, the configuration of the surface of this fault being a factor in localizing the individual ore shoots. The sulphide lens at the Collier mine has a somewhat similar relationship to a prominent fault, the flattening of the fault surface apparently being a factor of some significance.

At the Big Bend mine the ore body is developed between two intersecting, curving, high-angle faults that bound an elongate pod of folded, crushed, and fissured rock. The ore shoots at the Quail Hill mine are formed along faults and shear zones adjacent to the contact of a relatively massive intrusive rock, and particularly at salients or local irregularities on this contact. At the Jesse Belle mine intersections of shear zones have been a controlling factor in the location of ore shoots.

In some places, channelways and openings favorable for ore deposition apparently were formed by bowing, buckling, or cross-shearing of a strongly foliated zone or an older fault zone, resulting in steeply pitching chimneys of more intensely fissured and crushed rock. Such conditions probably occur at the Newton mine, and seem to have been an important factor in portions of the mineralized zones at the Penn mine.

Supergene Enrichment

The most important secondary sulphide in the deposits of the district is chalcocite, and in many of the mines it is accompanied by minor amounts of covellite. Tolman [38] states that rarely secondary chalcopyrite is present.

Throughout most of the district the top of the zone of supergene enrichment lies within 20 to 60 feet of the surface. The lower side of this zone is less definite. Veinlets of sooty chalcocite, in and adjacent to fault zones, were observed in the Quail Hill mine 200 feet below the surface, though the bulk of the supergene sulphides probably lay above the 70-foot level of the mine. At the Newton mine appreciable amounts of chalcocite were present in the upper 100 feet of the ore body, and some enrichment by chalcocite extended deeper adjacent to faults, in places to depths of 160 feet or more. Chalcocite was present as thin sooty coatings on primary sulphides on the 200 level of the Penn mine, approximately 160 feet below the surface.

Because the Sierra Nevada has been subjected to vigorous erosion during late geologic time, and the deep incision of the major streams during Quaternary time has caused a rapid lowering of the water table, the zone of supergene enrichment in the Foothill belt, is thin, as a rule, and the ores from this zone generally show only a moderate increase of tenor over the primary sulphides. Nevertheless, at the Newton mine the copper content of enriched ore recently mined averaged better than twice that of the deeper ore. Similarly, if local tradition can be trusted, the shallow sulphide ores of the Penn mine were notably high in copper content. These rather exceptional cases are probably a result of the proximity of the present erosion surface to an older (Tertiary) erosion surface at each of these localities, and much of the enrichment, therefore, possibly dates from the earlier erosion period.

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[38] Tolman, C. F., op. cit. p. 249.

Secondary zinc minerals are not common, and the accumulation of zinc by supergene processes probably was not an important process in the Foothill deposits.

Gossan and Oxidized Ore

The outcrops of ore bodies and the associated pyritized zones ordinarily are marked by gossans, some of them quite prominent, others less conspicuous. The leaching of the sulphides from the ore bodies near the surface left a porous mass of residual gangue material, mainly quartz, sericite, and barite. Added to this in the processes of weathering were hydrated iron oxides, kaolin, jarosite, and, locally, small amounts of copper carbonates.

As a general rule in the Foothill belt, those gossans developed from ores rich in copper are brown or yellow-brown, whereas those derived from predominantly pyritic material are, for the most part, shades of red-brown. In some places the leached outcrops show green or blue staining typical of oxidized copper minerals, and, less commonly, efflorescent salts of copper, zinc, or iron may be discerned as coatings on the more protected surfaces.

Many of the gossans contained enough residual gold to make it profitable to mine them for that metal. Further, the working of gossan material at the Quail Hill and the Valley View mines for gold led to the discovery of copper ore at greater depth. Both the Big Bend and the Blue Moon mines were shallow gold prospects until deeper exploration during the present decade disclosed the presence of appreciable amounts of zinc and copper sulphides below the water table.

The zone of oxidized ore generally does not extend to any great depth. Its bottom at the Newton mine lies between 12 and 35 feet below the surface, and its contact with the enriched sulphide ore is exceedingly sharp. Partly oxidized ore was observed in the Collier mine 40 feet below the surface, but sulphides within this ore are present to within 12 feet of the surface. At the neighboring Star-Excelsior mine the oxidized zone extends to a depth of more than 30 feet and at the Quail Hill mine to approximately 40 feet. Drill holes at the Eldorado mine indicate that some oxidation products, native copper and cuprite, are present to depths of 70 feet.

In the American Eagle-Blue Moon area, Mariposa County, complete oxidation of sulphides extends downward 40 to 70 feet and incomplete oxidation extends somewhat deeper along fault zones. At La Victoria mine, the sulphides are completely oxidized to 30 feet below the surface, and ore is partly oxidized to a depth of 80 feet or more. The oxidized ore at the Dairy Farm mine, Placer County, was mined as an open-pit, and Aubury[39] records that the oxidized ore continued downward 85 feet from the original surface. Reid,[40] who examined the Pocahontas mine, Mariposa County, when the underground workings were accessible, found the oxidized ore extended to 90 feet below the surface; he considered 90 feet exceptionally deep for the Foothill belt, and it is probably an extreme example.

Of the copper minerals in the oxidized zone, malachite and azurite are the commonest. Native copper is present in many of the deposits, but generally only in small quantities. Cuprite was observed at the

[39] Aubury, L. E., op. cit., p. 209.

[40] Reid, J. A., Foothill copper belt of the Sierra Nevada: Min. and Sci. Press, vol. 96, pp. 388-393, 1908.

Valley View, Eldorado, Star-Excelsior, and La Victoria mines, and chrysocolla was seen at the Valley View and Star-Excelsior mines. When Silliman visited the Quail Hill mine in 1867 the oxidized zone was being worked for gold and silver, and he noted[41] that chrysocolla, cuprite, and native copper were among the minerals present.

Origin of the Deposits

The genesis of the copper-zinc deposits of the Foothill belt has been a controversial subject, and a wide range of opinions has been voiced. One of the earliest views, expressed in 1895, was that of Lindgren and Turner[42] who had mapped the Foothill belt within the Smartsville quadrangle. They mention that ''small quantities of copper ore are frequently found, partly as fissure veins, partly as slight impregnations in the schists;'' referring to the deposit at Spenceville, they say it is ''evidently a local massing of copper and iron pyrites along one of the (quartz) veins.'' At a later date (1933) Lindgren[43] briefly summarized his views on the copper deposits of the belt, stating that they appear ''in places as 'fahlbands' in amphibolitic schists, as larger masses in quartz gangue, as narrow fissure veins with quartz gangue, pyrite, chalcopyrite, and some sphalerite. Their affiliations are in doubt. In part they have participated in the post-Mariposa dynamic metamorphism. They are apparently older than the gold-quartz veins.'' Turner[44] considers two of the deposits in Madera County—the Daulton (or Ne Plus Ultra) and the Buchanan—to belong to the contact-metamorphic type, because they are developed in mica and chiastolite schist adjacent to granitic intrusions.

In his discussion of the Foothill belt, Knopf[45] says little about the genesis of the deposits, except that they are ''all closely associated with meta-andesites, and belong to the general type of replacement deposits along shear zones. This gives a certain geologic unity to the entire belt. The replacement has been equally thorough in very diverse rocks, producing the large ore bodies of Copperopolis in chlorite schists, and the extensive, and more massive, ore bodies of Campo Seco in quartz porphyry schists.''

In 1908, at a time when many of the mines were accessible, the district was discussed in two brief papers, one by Reid,[46] the other by Forstner.[47] With regard to the origin of the deposits, Reid concludes that the copper ores are related to hornblendite and allied species of rocks, in contradistinction to the gold-quartz veins and deposits of auriferous pyrite, which he considers to be later in age and related to the acid intrusive rocks (that is, granodiorite, etc.) of the belt. His affiliating the copper ores with the hornblendite is apparently based in

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[41] Silliman, B., Jr., Notice of the peculiar mode of the occurrence of gold and silver in the foothills of the Sierra Nevada, and especially at Whiskey Hill, in Placer County, and Quail Hill, in Calaveras County, California: Am. Jour. Sci., 2d ser., vol. 45, pp. 92-95, 1868.

[42] Lindgren, W., and Turner, H. W., U. S. Geol. Survey Geol. Atlas, Smartsville folio (no. 18), p. 6, 1895.

[43] Lindgren, W., Ore deposits of the Western States (Lindgren volume), p. 169, Am. Inst. Min. Met. Eng., 1933.

[44] Turner, H. W., Notes on contact-metamorphic deposits in the Sierra Nevada Mountains: Am. Inst. Min. Eng. Trans., vol. 34, pp. 666-668, 1904.

[45] Knopf, A., Notes on the Foothill copper belt of the Sierra Nevada: Univ. California, Dept. Geol. Sci. Bull., vol. 4, pp. 411-423, 1906.

[46] Reid, J. A., Foothill copper belt of the Sierra Nevada: Min. and Sci. Press, vol. 96, pp. 388-393, 1908.

[47] Forstner, W., Copper deposits in the western foothills of the Sierra Nevada: Min. and Sci. Press, vol. 96, pp. 743-748, 1908.

large part on his observing in hornblendite at Copperopolis that "the chalcopyrite is intergrown with the hornblende, and in the hand specimens grains can often be seen entirely within the boundaries of large unaltered hornblendes."[48] Forstner's views on genesis are somewhat different, for he believes the sulphide bodies at the Penn mine "are related to the quartz-porphyry intrusions, and are later than the movements causing the schistosity in them"; he also states "there is reason to believe that [the copper deposits of the western foothills] are genetically related to the late Jurassic or early Cretaceous eruptions".

Hulin[49] in 1933 discussed the geological relations of ore deposits in California, and referring to the Foothill belt says that "the deposits occur as veins and replacements in amphibolites. Although usually classed as genetically related to the Sierra Nevada batholith, they are possibly earlier."

In a brief summary of his views on the genesis of ore in the copper-zinc belt, Tolman[50] states that "with the doubtful exception of pyrite, accompanied by silicification, the sulphides were introduced after the metamorphism of the country rock . . . Like the gold mineralization of the Sierra Nevada, the copper mineralization of the Foothill belt was later than the intrusion of the Sierra Nevada batholith, and subsequent to the contact metamorphism connected therewith."

The latest opinion to be expressed on the origin of copper and zinc ores in this district is that of MacDonald (1941),[51] who studied two of the mines in Fresno County. He favors the view that the sulphide deposits were formed prior to the dynamothermal metamorphism of the region, and that contemporaneously with the metamorphism "the ore bodies were recrystallized into a metamorphic texture in which euhedral needles of hornblende penetrated anhedral sulfides."

The writer supports the hypothesis of Tolman and others that the sulphide deposits of the Foothill belt are genetically related to the Sierra Nevada granodiorite pluton. With the exception of the typical pyrometasomatic deposits, they have been localized primarily by structural features, which are, for the most part, fault zones, shear zones, and crushed zones. Though formed after the regional orogeny, the concomitant metamorphism, and the emplacement of the granodiorite, the stresses of that diastrophism either were not completely relieved or were renewed, resulting in inter-ore and post-ore deformation, which in many of the deposits is evidenced by some displacement of ore along the same faults and shear zones that earlier controlled deposition, and in certain cases is also indicated by the development of crystalloblastic textures in the ores and by the production of pressure shadows around sulphide crystals.

The fact that the major structural controls of the ore bodies in most of the mines of the copper-zinc belt are faults, shear zones, and zones of brecciation related to movement along geologic contacts, seems to be strong evidence that the introduction of the ore-forming solutions and the deposition of ore were events and processes that occurred after the

[48] Reid, J. A., The ore deposits of Copperopolis, California: Econ. Geology, vol. 2, p. 391, 1907.

[49] Hulin, C. D., Ore deposits of the Western States (Lindgren volume), p. 247, Am. Inst. Min. Met. Eng., 1933.

[50] Tolman, C. F., op. cit., pp. 249-250.

[51] MacDonald, G. A., Geology of the western Sierra Nevada between Kings and San Joaquin Rivers, California: Univ. California, Dept. Geol. Sci. Bull., vol. 26, pp. 267-269, 1941.

regional orogeny, that is, after the structural grain of the country had been established. Such details as the presence of undeformed veinlets of ore within gouge of major faults, as can be seen in the North Keystone and Quail Hill mines, corroborate this view. That the ore is later than metamorphic structures such as schistosity and foliation is indicated by the presence of small pencils of undeformed sulphide developed along and within the axial regions of minor schistosity folds, as at the Penn mine, and by the occurrence of greater amounts of iron, copper, or zinc sulphides along certain faults showing drag in the foliation of the contiguous country rock, but with no evidence of local postsulphide movement, as can be seen in places in the Penn and North Keystone mines. Likewise, the preservation of schistose layering in banded ores, suggesting selective replacement of foliated rocks, and the common occurrence of the ore deposits of the belt in zones of strongly developed schistosity or cleavage, seem to confirm the view that the metamorphism of the region preceded the introduction of ore.

It must be emphasized, however, that all deformation in the region did not cease with the emplacement of the batholith. There is evidence both within the main body of granodiorite and within satellitic intrusions, that stresses continued to be effective and were relieved by local deformation. Cloos [52] has described primary flexures showing reverse movement within the granodiorite batholith along the south extension of the Mother Lode fault zone near Mariposa. The boundaries of the flexure zone are indistinct and gradational, indicating the magma was in a plastic and flexible condition when the movement took place.

Deformation in granodiorite after its complete solidification is manifest in the North Keystone mine, where many portions of a large sill-like intrusion, along with quartz veins contained in it, show strong cataclastic deformation. In addition, within restricted portions of the body, quartz-augen chlorite schist has been developed from the typical granodiorite by intense shearing of the rock. Foliation is evident in parts of this intrusion, as well as in others in the Foothill belt, and it is important to note that the presence of such structure in an igneous rock is not necessarily a criterion of its age, but in many cases merely indicates the body lies within a zone along which deformation occurred during or after the emplacement of the magma.

Some of the copper-zinc ore bodies show conclusive evidence that local deformation was active during or after the deposition of the sulphides. The crystalloblastic textures of some of the ore in the Blue Moon and Penn mines, and the pressure shadows developed around pyrite cubes in the alteration zone at the American Eagle prospect are indicative of stresses active since the introduction of sulphides. Fragments of ore in the breccia of the fault zone on the hanging wall of the main ore shoot at the Blue Moon mine certainly demonstrate post-ore movement along the margin of that ore body. A certain amount of post-ore movement along faults developed prior to or during the deposition of ore is indicated also in the Big Bend mine.[53] Faults offsetting ore a few inches to tens of feet have been mapped in the Newton, Penn, and North Keystone mines. At the Newton mine this faulting is transverse to the ore

[52] Cloos, E., Mother Lode and Sierra Nevada batholith: Jour. Geology, vol. 43, pp. 241, 243-246, 1935.
[53] Messner, W. E., and Bein, H. H., California producer solves difficult flotation problem: Eng. and Min. Jour., vol. 145, no. 11, p. 70, 1944.

body, whereas at the Penn and North Keystone mines the ore has been displaced by dip-slip movement along reverse faults.

There is also good evidence that the copper-zinc ores are of later date than the emplacement of the granodiorite pluton and its satellitic stocks. Chalcopyrite and pyrite are present as streaks formed by replacement, and as veins, in granodiorite at the North Keystone mine, and at the Funny Bug mine in El Dorado County. A geologic map by Reid [54] of the 100-foot level of the Pocahontas mine shows lenses of ore made up of chalcopyrite, sphalerite, and pyrite occurring along the contact and within the granitoid stock that crops out immediately south of the mine. In a number of other cases, as the Spenceville, Valley View, Salambo, White Rock, Lone Tree, Green Mountain, Jesse Belle, Daulton, and Copper King mines (pl. 1), the ore deposits are suggestively close to, and in certain instances clustered around, granodiorite bodies or intrusions of similar composition.

Emmons,[55] and later Tolman,[56] have pointed out that the western slope of the Sierra Nevada, when viewed as a metallogenetic province, shows a broad regional zoning with respect to the batholithic mass. These zones lie parallel to the Mother Lode, a belt of predominantly mesothermal deposits; eastward, southward, and northward toward the major granodiorite intrusions, mineral associations typical of higher temperatures are to be found. Such are the tourmaline-bearing auriferous veins of Meadow Lake,[57] Nevada County, and the copper deposits at the Superior and the Walker mines,[58] Plumas County, where tourmalinization, likewise, has been important. Similarly, many of the gold deposits of the East belt, such as the Shady Run mine,[59] Placer County, and the Cooke mine,[60] Calaveras County, are characterized by an abundance of arsenopyrite. The Foothill copper-zinc belt exhibits a somewhat analogous regional distribution of temperature types, with those formed at higher temperatures, characterized by pyrrhotite, becoming more abundant southward where the main mass of granodiorite is approached. It also seems significant that the deposits highest in zinc content lie at considerable distances from the exposed edge of the batholith, such deposits being particularly common in the western part of the belt in Mariposa and Calaveras Counties. Thus, this regional distribution of the Sierra Nevada gold-quartz deposits and the copper-zinc replacement deposits, when viewed as a whole, suggests that both are the consequence of widespread metallization genetically related to the Sierra Nevada pluton.

POTENTIALITIES OF THE DISTRICT

Very few portions of the Foothill copper-zinc belt have been adequately prospected in the modern sense of the term. Small-scale operations, allowing little or no funds for methodical exploration, have been

[54] Reid, J. A., Foothill copper belt of the Sierra Nevada: Min. and Sci. Press, vol. 96, pp. 388-393, 1908.

[55] Emmons, W. H., op. cit., p. 348.

[56] Tolman, C. F., op. cit., p. 250.

[57] Lindgren, W., The auriferous veins of Meadow Lake, Califonia: Am. Jour. Sci., 3d ser., vol. 46, pp. 201-206, 1893.

[58] Knopf, A., The Plumas County copper belt of California in Copper Resources of the World, pp. 243-244, Washington, 16th Internat. Geol. Cong., 1935.

[59] Reid, J. A., The country east of the Mother Lode: Min. and Sci. Press, vol. 94, pp. 279-280, 1907.

[60] Turner, H. W., and Ransome, F. L., U. S. Geol. Survey Geol. Atlas, Big Trees folio (no. 51), p. 8, 1898.

the rule in the district, and in many of the mines even the mineralized zones that contain exploited ore have not been thoroughly tested by crosscutting or diamond drilling for additional ore bodies. Though ore shoots that do not extend to the surface are present in several of the mines, surface prospecting in the district has been almost entirely limited to the search for favorable gossans, accompanied by limited exploration of the ground in their immediate vicinity.

Systematic geologic mapping delineating the structure of the rocks should disclose those portions of the belt particularly favorable to ore deposition. Within such areas, geologic work in greater detail, possibly aided by geophysical methods or aerial color photography, will in many cases be necessary to define specific localities where exploration by trenching, drilling, or other means is advisable. It is believed that a broad, methodical program, consistently carried out along such lines, would with little doubt disclose additional metal reserves.

It seems reasonable to conclude, therefore, that the Foothill belt offers real opportunities for the discovery of untouched ore deposits, that can be profitably mined under favorable economic conditions.

ZINC-COPPER DEPOSITS OF THE BIG BEND MINE, BUTTE COUNTY, CALIFORNIA *

By John H. Eric **

OUTLINE OF REPORT

ILLUSTRATIONS

ABSTRACT

The zinc-copper deposits at the Big Bend mine are in slightly metamorphosed volcanic rocks. Schistosity and contacts strike northwest and dip steeply northeastward. In the mine there is a braided fault zone, consisting of several curving, intersecting, steeply dipping faults. The rocks within part of this zone have been hydrothermally altered to pyritic sericite schist.

The ore body is a steeply dipping sulphide replacement deposit within or at the hanging wall of the alteration zone. It has a pitch length of about 350 feet, a maximum strike length of 140 feet, a maximum width of nearly 40 feet, and an average width of 10 feet. The sulphides are pyrite, sphalerite, chalcopyrite, with minor galena, bornite, and tetrahedrite. Barite and quartz are the principal gangue minerals.

Approximately 29,000 tons of ore averaging about 13 percent zinc, 2 percent copper, and 0.2 percent lead was extracted from May 1943 through December 1945. Two areas are favorable for exploration: (1) the downward extension of a hanging-wall mineralized zone, and, more important, (2) the downward extension of the ore body.

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* Published by permission of the Director, Geological Survey, U. S. Department of the Interior. Manuscript submitted for publication March 1, 1948.

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INTRODUCTION

Location and Topography

The Big Bend mine (pl. 1) is in central Butte County, California, and lies in sec. 8, T. 21 N., R. 5 E., Mount Diablo base and meridian. From Oroville the mine is reached by following the Feather River highway northeastward 20 miles, thence by 3 miles of macadam road and 3 miles of nonsurfaced road. The nearest rail shipping point is Pulga, 12 miles to the north.

The mine is in the western foothills of the Sierra Nevada on the southeast end of Big Bend Mountain, at the brink of the canyon of the North Fork of the Feather River. The average elevation is about 2,500 feet. To the north and east are rolling, forested hills; to the south and west are the steep slopes of the canyon (pl. 2). The soil is thick, and outcrops are not abundant except on the canyon slopes.

Ownership and Development

The Big Bend mine is on the Edna May claim and is owned by E. F. Allingham of Route 1, Oroville, California; from 1942 through 1945 it was operated under lease by Hoefling Brothers of Sacramento.

In 1945 the mine consisted of a steeply inclined shaft 338 feet deep, with levels at 51, 101, 177, 273, and 323 feet (vertical distances), and two sublevels, shown on plates 3 and 4. Drifts and crosscuts totaled about 1,400 feet. Stopes extended from the 5th level up to the bottom of the oxidized zone, and are shown on plate 4.

Near the mine are several pits, trenches, shallow shafts, and short adits, most of which are shown on the surface map (pl. 2).

Field Work and Acknowledgments

The Big Bend mine was studied during 1945 as part of the U. S. Geological Survey's wartime investigations of the Foothill copper-zinc belt. A preliminary examination was made on March 18-19, 1945, by G. R. Heyl and the writer. A more detailed study was undertaken during the first half of June 1945. At that time mining of shaft pillars and filling of stopes had begun. Much of the mine was inaccessible, and in many of the accessible parts the walls were concealed by lagging or the ore removed by stoping. Extensive use has therefore been made of company geologic maps prepared by H. H. Bein.

The writer gratefully acknowledges aid and information given by Hoefling Brothers, particularly by A. E. Jones, general manager, W. E. Messner, superintendent, and H. H. Bein, geologist and metallurgist; and by E. F. Allingham, owner and lessor. Geologic maps, logs of drill holes, assay data, smelter returns, and production figures have been made available. The surface map (pl. 2) is largely the work of F. H. Frederick and H. H. Bein; the main additions by the writer are attitude of schistosity, and contacts between altered rock and greenstone and between metafelsite and greenstone.

During the present study no thin-sections were examined, hence the rock names used in this paper are field terms only.

HISTORY AND PRODUCTION

Prior to 1942 the only development at the Big Bend mine consisted of an adit about 140 feet long, probably driven late in the nineteenth century as a gold prospect, and a winze about 10 feet deep. These workings were formerly known as the Evening Star claim.[1] The adit, which explores a narrow gossan shown on plate 3, later became the 1st level.

Early in 1942 the Edna May claim was acquired by E. F. Allingham, who raised through from the winze to the surface, 50 feet above.[2] The raise and winze formed what is now the upper part of the shaft.

In October 1942 the property was leased by Hoefling Brothers. During the winter of 1942-43 a three-mile access road was built; milling began in May 1943, and the first concentrates were shipped the following month.

During 1944 and 1945 Hoefling Brothers put down about 5,000 feet of diamond-drill holes, both from the surface north of the mine and from underground workings, shown on plates 2-5. Several trenches also were dug.

In October 1944 the operators conducted a geophysical survey of the area. This work, using the spontaneous polarization or self-potential method, was started by Sulhi Yungul and Fernando Nieri, and continued by H. H. Bein a little later in the same year. The surface drill holes were designed to explore negative potential centers disclosed by this survey, but no ore was encountered.

Ore from the Big Bend mine was hauled by truck four miles to the converted flotation mill at the Surcease gold mine, owned by Hoefling Brothers. The two mill products, a zinc concentrate and a copper-lead concentrate, were hauled by truck 12 miles to the Western Pacific Railroad at Pulga, California, whence the zinc concentrate was shipped to the Sullivan Mining Company's smelter at Kellogg, Idaho, and the copper-lead concentrate to the International Smelting and Refining Company's smelter at Tooele, Utah.

Production figures of the Big Bend mine, from May 1943 through December 1945, are shown in table 1. In addition, a small quantity of concentrates was shipped early in 1946.

Table 1. Production of the Big Bend mine [1]

Period	Ore (tons)	Copper[2] (pounds)	Zinc[2] (pounds)	Lead[2] (pounds)	Gold (ounces)	Silver (ounces)
1943	3,940	128,000	814,000	16,000	186	5,297
1944	14,297	486,000	2,888,000	54,000	563	10,897
1945	10,580	390,000	2,502,000	48,000	540	18,751
Totals	28,817	1,004,000	6,204,000	118,000	1,289	34,945

[1] Minerals Yearbook, U. S. Bureau of Mines, 1943-1945.
[2] Pounds of recovered metal.

Daily production averaged about 30 tons. By June 1945 most of the ore had been stoped out, and operations were limited to the mining of shaft pillars. As pillars were removed the stopes were filled with waste, and at the conclusion of operations in December 1945 the four lower levels were inaccessible. Pillars had been removed to about 30 feet above the 3d level when the shaft caved and the mine was abandoned.[3]

[1] Logan, C. A., Sacramento field division—Butte County: California Div. Mines Rept. 26, pp. 372-373, 1930.
[2] Messner, W. E., and Bein, H. H., California producer solves difficult flotation problem: Eng. Min. Jour., vol. 145, no. 11, pp. 68-71, 1944.
[3] Bein, H. H., Personal communication.

GENERAL GEOLOGY

The Big Bend mine lies about 7 miles east of the western edge of the Sierra Nevada, where pre-Cretaceous metamorphic and intrusive rocks of the range are overlapped by flat-lying rocks of the Sacramento Valley. The metamorphic rocks near the mine consist dominantly of metavolcanics, which collectively were designated "amphibolite" by Turner.[4] About half a mile northwest of the mine a band of micaceous slates was mapped by Turner as the Calaveras formation of Carboniferous age. About 1,200 to 1,500 feet east of the mine are slates that may also belong to the Calaveras. The metavolcanics consist mainly of greenstone and chlorite schist derived from mafic to intermediate flows and tuffs. Locally they have been converted by hydrothermal alteration into sericite schist, and it is within this schist that the ore occurs.

In general, schistosity and contacts strike west of north and dip steeply northeastward. If the sinuous pattern of the contact between the Calaveras formation and the amphibolite, shown on Turner's map, is caused by folding, the area lies near the axis of a northwestward-trending fold. Certain relations near the mine, described below, suggest that the top of the section may be toward the west, and that the rocks are therefore overturned. A more definite interpretation will have to await detailed regional geologic mapping.

Although deposits of base metals in Butte County have been known for some time[5] they have apparently never been considered as part of the Foothill copper-zinc belt. Heretofore, the north end of this belt generally has been considered to be in the vicinity of Spenceville, in western Nevada County. The occurrence and character of ore at the Big Bend mine are typical of the zinc-copper deposits of the Foothill belt, indicating that the belt extends at least 40 miles farther north than had previously been thought.

METAVOLCANIC ROCKS

Greenstone and Chlorite Schist

The rocks enclosing the Big Bend ore body and underlying most of the adjacent area are dark colored and consist dominantly of greenstone and chlorite schist.

The greenstone is massive to poorly foliated, medium to dark green, and weathers brown. It is composed of subhedral white feldspar as much as 3 or 4 millimeters in diameter, chlorite, and a little epidote and pyrite. The chlorite schist is generally dark green and weathers to shades of brown and gray. It contains chlorite, a little feldspar, sericite, epidote, and pyrite.

Much of the greenstone is porphyritic and probably represents flows, although northwest of the map-area (pl. 2) there are a few exposures of medium- to fine-grained tuff. Just west of the mine are scattered outcrops of chlorite schist containing abundant spheroidal amygdules of granular quartz 1 to 4 millimeters in diameter. It seems likely, therefore, that most of the dark-colored metavolcanics near the mine were originally mafic flows.

[4] Turner, H. W., U. S. Geol. Survey Geol. Atlas, Bidwell Bar folio (no. 43), 1898.
[5] Logan, C. A., op. cit., pp. 372-373, 378.

Metafelsite

East of the mine is an area underlain by light-colored metafelsite. Near the south end of the map-area this unit has an outcrop width of 350 feet, but it thins northward and pinches out about 1,200 feet northwest of the Big Bend shaft. The irregular west contact of the metafelsite is plotted in part from logs of drill cores, and probably signifies either interfingering, faulting, or folding. A small lentil of metafelsite crops out near the trenches just northwest of the mine, and scattered exposures occur within mine workings.

Most of the metafelsite is massive, and probably represents either flows or shallow intrusive bodies. The rock consists of small white euhedral crystals of feldspar, generally less than than one millimeter in diameter, in an aphanitic to fine-grained gray to blue-gray matrix that is probably mainly quartz and feldspar. The rock weathers to light gray to buff.

A smaller amount of the metafelsite is schistose and coarser-grained, and contains a little sericite in addition to other minerals. This type may represent felsic tuffs or may result from shearing of the massive type.

In greenstone, near the western contact of the metafelsite, are small rounded stretched fragments of metafelsite, generally less than 5 centimeters long, which plunge nearly down-dip. If the included metafelsite fragments were derived from the main mass of metafelsite, then the western greenstone must be the younger rock. Furthermore, because the greenstone appears to be extrusive, and structurally dips beneath the western contact of the metafelsite, the stratigraphic section here is probably overturned.

INTRUSIVE ROCKS

Mafic Dikes

Within greenstone and chlorite schist are swarms of massive mafic dikes ranging in thickness from a fraction of an inch to 10 feet or more. (None of these dikes is shown on the map.) They have been intensely folded. Under the hand lens they are seen to be composed of feldspar, chlorite, epidote and, in places, euhedral metacrysts of pyrite. A few tiny crystals of a dark-green mineral, possibly uralite, are barely visible under the hand lens. The dikes are gray green, and weather to soft claylike material that is gray, pale buff, yellow, or red, the color possibly becoming redder with increase of ferric iron.

Although no mafic dikes were seen within the main body of metafelsite, they were found intruding scattered exposures of metafelsite in mine workings, and are therefore younger than all the metavolcanic rocks. Mafic dikes are even found in massive ore, but in these instances they have been only slightly replaced by the mineralizing solutions. The structure and composition of the dikes indicate that they were subjected to folding and low-grade metamorphism.

Feldspar Porphyry Dikes

Two small dikes of massive feldspar porphyry are exposed on the 3d level (pl. 3), and several small outcrops of this rock were seen on the surface south and east of the map-area. The rock is light gray in color and consists of many euhedral white plagioclase phenocrysts and scattered vitreous quartz phenocrysts with a little chlorite and pyrite in a fine-grained light-gray matrix. Some of the plagioclase phenocrysts are as large as one centimeter in diameter, the quartz as large as 5 millimeters.

The feldspar porphyry contains inclusions of chlorite schist and mafic dikes, and is thus younger than the other rocks. The absence of foliation and of large quantities of secondary minerals indicates it is probably also younger than most of the regional metamorphism. If the matrix contains appreciable potash feldspar, the rock probably is granodiorite porphyry.

ROCK ALTERATION AND QUARTZ VEINS

Hydrothermal Alteration

Hydrothermally altered rocks form one or both walls of the ore body. These altered rocks occupy a zone, about 500 feet long and as much as 40 feet wide, in which sericitization, pyritization, and silicification have been superimposed on the greenstone and chlorite schist.

In general sericitization and pyritization are far more strongly developed than silicification, and the principal type of altered rock is pyritic sericite schist. In most cases the transition between sericite schist and chlorite schist or greenstone is fairly abrupt. The pyrite in the sericite schist varies from sparsely disseminated euhedral cubes to massive seams as much as 3 or 4 feet thick.

In addition to the main alteration zone several smaller zones have been intersected in drill holes (pl. 3). A few small scattered exposures of altered rock were seen on the surface, away from the main alteration zone, but because of their paltry size and uncertain extent they are not indicated on plate 2.

Mafic dikes that occur within hydrothermally altered rocks are themselves relatively unaltered except for the presence of pyrite, which occurs both within and without the alteration zone. The outer margins of some of the dikes are lighter colored than the centers, suggesting either leaching of chlorite or original differences in composition. The chlorite in the dikes is probably derived from regional metamorphism rather than hydrothermal alteration, as it is widespread and by no means confined to the alteration zone.

Quartz Veins

Veins of milky quartz occur throughout the area, but are more abundant in the southern part; the largest of them are shown on the surface map (pl. 2). The veins range in thickness from a fraction of an inch to 4 or 5 feet. Besides quartz, the minerals present include pyrite, chlorite, epidote, a little calcite and chalcopyrite, and, at the surface, small spots of chalcocite and covellite. Assays of these veins and adjacent walls show little or no gold. There are gold mines a few miles to the west.

STRUCTURE

Schistosity and Lineation

Schistosity is very well developed in sericite schist, well developed in chlorite schist, poorly developed to incipient in greenstone, and absent in most of the metafelsite and the dikes. The great fissility of the sericite schist may have been inherited from a braided fault zone antedating but intimately associated with the alteration zone. This fault zone, which is described below, consists of several curving, intersecting faults, and it is probable that the ground between the faults is highly sheared in places. The schistosity resulting from such shearing appears to have been emphasized by later alteration of chlorite to sericite. It should be pointed out, however, that the alteration zone occupies only a part of the fault zone, (pl. 3), and unaltered rocks within the fault zone are not particularly sheared.

Schistosity strikes N. 15°-60° W., and generally dips 50°-90° northeastward. In the lower mine-workings, however, vertical and steep westerly dips are common.

Linear elements consisting of crinkles in schistosity surfaces occur in sericite schist and chlorite schist. At most places these crinkles are minute, but on the 3d level hanging-wall drift they have wave lengths of several inches and resemble mullions. The lineations plunge[6] northward 60°-70°, parallel to the plunge of the ore body.

Folds

One of the conspicuous features in the main alteration zone is the presence of intensely folded mafic dikes.[7] Folds occur in dikes of all sizes, and range from broad rolls to tight, nearly isoclinal folds. They apparently pitch at all angles and in all directions, although folds with nearly horizontal axes parallel to schistosity in adjacent sericite schist are common. Drag folds in schistosity are abundant along faults.

Faults

The principal faults are known as the South fault, forming the southern boundary of the ore body, and the North fault (pls. 3, 4, fig. 1). In places these faults are single fissures, in others they are actually fault zones.

In general the South fault strikes north and dips steeply westward, although in many places the strike is east or west of north and the dip is vertical or even eastward. On the 5th level, the South fault dips 30° westward.

The North fault is similar to the South fault except that in general it dips steeply eastward. Its strike ranges from slightly east of north to northwest.

Between and beyond these two curving faults are other faults, some of which connect the two principal faults. Together, the faults constitute a braided fault zone that strikes about parallel to schistosity. The intersection of the two principal faults has nowhere been observed. A hanging-wall split of the North fault was observed dipping 30° eastward on the 5th level intermediate; just below, on the 5th level, it was absent, so that it either dies out with depth or flattens to horizontal just above the 5th level and joins the South fault at a low angle (pl. 4, fig. 1).

Most of the fault movement appears to have been pre-ore, although there was slight post-ore movement. The evidence for pre-ore movement is hydrothermal alteration within a pre-existing fault zone, ore cutting across some of the faults, and absence of ore fragments in the fault gouge where ore is parallel to an adjacent fault. Moreover, it appears that both the North and South faults antedate ore deposition and were a controlling factor in localizing ore (described below). Some post-ore movement took place on the North fault, as well as on other faults, for the North fault displaces ore on the 4th level and 5th level intermediate (pl. 3), and

[6] Plunge, as here used, is defined as the vertical angle between a horizontal plane and the line of maximum elongation.

[7] Messner, W. E., and Bein, H. H., op. cit. photograph, p. 70.

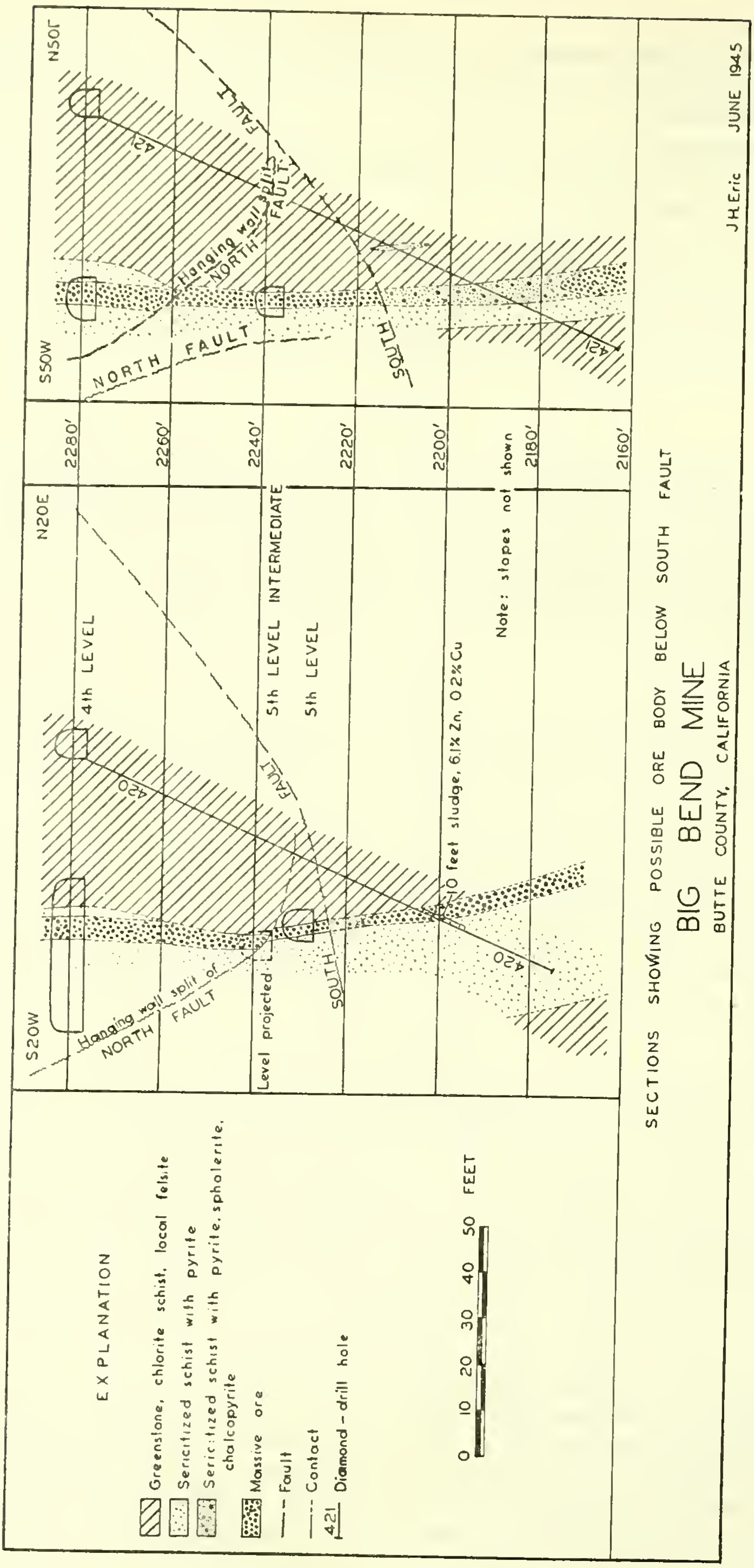
EXPLANATION
Greenstone, chlorite schist, local felsite
Sericitized schist with pyrite
Sericitized schist with pyrite, sphalerite, chalcopyrite
Massive ore
Fault
Contact
421 Diamond-drill hole
0 10 20 30 40 50 FEET
S20W
N20E
S50W
N50E
4th LEVEL
5th LEVEL INTERMEDIATE
5th LEVEL
Level projected
Hanging wall split of NORTH FAULT
NORTH FAULT
SOUTH
FAULT
420
421
10 feet sludge, 6.1% Zn, 0.2% Cu
Note: stopes not shown
2280′
2260′
2240′
2220′
2200′
2180′
2160′
SECTIONS SHOWING POSSIBLE ORE BODY BELOW SOUTH FAULT
BIG BEND MINE
BUTTE COUNTY, CALIFORNIA
J.H.Eric JUNE 1945

FIG. 1

several inches of brecciated ore are present in the north stope 30 feet above the 4th level.

The North and South faults have not been observed at the surface because of the paucity of outcrops; presumably, however, they do reach the surface. A split of the South fault is exposed just east of the portal of the 1st level (pl. 3), and the gulley just east of the shaft (pl. 2) may be the topographic expression of the South fault zone.

Drag folds in schistosity, wherever seen, indicate normal movement along faults. But because of the steepness of schistosity and contacts, and the metamorphism and compression that the region has undergone, it seems likely that these drag folds represent only the latest movement, and that most of the faults were originally thrusts. Post-ore movement on the North fault was rotational, for the direction of displacement of ore is reversed on the 4th level and 5th level intermediate (pl. 3).

ORE BODY

General Features

The ore body is a steeply pitching lenticular sulphide deposit within or at the hanging wall of the alteration zone (pls. 3 and 4). The dip is approximately parallel to schistosity; at the shaft the dip is about 80° northeastward at the surface, flattens to 60° at the 1st level, steepens to 70° below the 2d level, and becomes progressively steeper from below the 3d to above the 4th level, whence it continues vertically downward. The pitch ranges from 60° to 75° and averages 70° northward, parallel to lineation in the wallrocks. The pitch length is about 350 feet, although the deposit was minable for only about 250 feet along the pitch; the maximum strike length is 140 feet; and the maximum width is nearly 40 feet, between the 2d and 3d levels. The area of maximum width is shown on plate 4. The ore body flattens slightly above this area, and steepens notably below. The average width of most of the stoped-out portion of the ore body is said to have been 10 feet.

At most places the footwall consists of sericite schist with abundant pyrite, either as disseminated euhedral grains or as massive stringers. On parts of the lower levels, however, the hanging wall also is sericitized, although it is less strongly pyritized than the footwall. In the lower parts of the mine, therefore, ore in general is within the alteration zone, rather than at the hanging wall.

Characteristics of the Ore

Ore at the Big Bend mine is generally massive and banded. The bands commonly range in thickness from a fraction of an inch to 2 inches, but most are less than 1 inch thick. They consist of alternating layers rich in sphalerite and in pyrite-chalcopyrite.

Primary sulphides are pyrite, sphalerite, and chalcopyrite, with galena and a little bornite. Tetrahedrite has been reported.[8] Gangue minerals are barite, milky quartz, calcite, and sericite. Some massive ore contains light-green acicular amphibole crystals, less than 1 centimeter long, that are probably actinolite.

Pyrite occurs as cubes and as anhedral grains. It is found in ore, as disseminations and massive stringers in sericite schist, and in quartz veins. Although usually it is fine-grained, cubes as much as 5 millimeters

[8] Messner, W. E., and Bein, H. H., op. cit.

in diameter occur in quartz veins. At one place, within sericite schist in the north stope about 15 feet below the 4th level, there is a layer of massive pyrite more than 4 feet thick.

Sphalerite is of two varieties that commonly occur together. One is a steel-black variety that probably contains appreciable iron; the other, which is more abundant, is pale brownish-yellow. Grains larger than 1 millimeter in diameter are rare. Sphalerite-rich bands are generally relatively free from pyrite.

Chalcopyrite is typically fine-grained. It is usually associated with pyrite, and chalcopyrite-rich bands commonly occupy parts of pyrite-rich layers. At one place, however, on the 3d level about 30 feet southeast of the shaft, there was a zone about 1 foot thick composed of nearly pure chalcopyrite.

Only a few grains of galena were seen; presumably most of it is very fine-grained.

Bornite was observed only in irregular quartz-calcite-chlorite-sphalerite-chalcopyrite-bornite veins. These veins, which cut massive sulphides, are generally only a few inches thick, and are of no economic importance.

Barite, the commonest gangue mineral, is found as small grains intimately intergrown with sphalerite; it also occurs as streaks or thin bands both in ore and in sericite schist. Fine-grained milky quartz is found throughout the ore body, but seems to be more abundant in the lower parts of the mine.

The average grade of ore mined was about 13 percent zinc and 2 percent copper. Production figures show that the ratio of lead to copper was 1 to 10; therefore the lead content was about 0.2 percent, assuming that the relative loss in milling was about equal for the two metals. Only the 2d level has been thoroughly sampled: the weighted average of 20 samples is 15.4 percent zinc and 3.7 percent copper, over an average width of 4 feet and a length of 110 feet.

The outcrop of the ore is a yellowish to reddish brown sericitic gossan containing barite and quartz. On the 1st level considerable claylike material is present, particularly within the alteration zone; this may be derived from mafic dikes. Two fairly high copper assays (about 6.5 percent), allegedly from the reddish gossan just below the 1st level, suggest that some cuprite may be present. Logan,[9] however, states that at about this locality in the Evening Star prospect there was "an 8-inch vein of heavy sulphide carrying from 6.62 percent to 13 percent copper, 1 to 5 oz. silver, 80 cents gold and some zinc." This suggests strongly that the high copper assays were obtained from chalcocite rather than cuprite. No secondary zinc minerals have been recognized.

Near the shaft complete oxidation of sulphides has extended to about 10 feet below the 1st level, or about 60 feet below the surface (pl. 4). Below this level is a partly oxidized zone about 10 feet in vertical thickness containing sphalerite, chalcocite, a little covellite, and stains of copper carbonates. The 2d level, about 100 feet below the surface, is developed in primary ore partly enriched by chalcocite and a little covellite. Because it was virtually impossible to separate the chalcocite from the sphalerite,[10] some of the more enriched copper ore was not mined. Small amounts of sooty chalcocite are present even in the deepest parts of the mine, particularly along faults.

[9] Logan, C. A., op. cit.
[10] Messner, W. E., and Bein, H. H., op. cit., pp. 69-70.

Ore Controls

The alteration zone in which ore occurs is associated with a fault zone which comprises the North and South faults and several subsidiary faults. It is believed that localization of hydrothermal alteration of the greenstone and chlorite schist was due largely to the presence of this fault zone. Ore is found only within and adjacent to altered rock.

The South fault appears to have been the principal structural feature that controlled mineralization. It forms the southern limit of ore nearly everywhere above the 5th level, except at some places where the fault consists of a number of splits and ore occurs below or south of some splits—as on the 4th level where a narrow seam of ore extends southward between two splits of the fault, and on the 2d level where a small amount of ore was stoped south of one of the splits. Above the 5th level ore appears to be restricted to the hanging-wall side of the South fault. Neither ore nor altered rock has been observed beneath the main fault zone. However, below the 5th level it is possible that ore may occur on the footwall side of the South fault. This occurrence is suggested by the discovery of sulphides below the 5th level in holes 420 and 421. The westward dip of the South fault flattens to 30° on the 5th level, and if the fault maintains this relatively flat dip below the level, then the mineralized ground intersected in holes 420 and 421 would be on the footwall side of the South fault.

The North fault also controlled ore deposition, but its effect is far less pronounced than that of the South fault. The north limit of ore (pl. 4) is approximately parallel to the trace of the ore body on the South fault. On the upper levels, ore does not extend north to the North fault, but on the lower levels ore occurs north of the North fault. Thus on the 4th level ore extends north of the North fault, but is narrower and lower in grade than to the south of the fault. On the 5th level intermediate, north of the North fault, ore is higher in zinc but lower in copper than it is to the south (pl. 3) ; furthermore, there are more mafic dikes (not shown on the map) to the north. They have the effect of splitting the ore into thin layers.

The influence of mafic dikes on ore deposition is not precisely known. The dikes have not been sericitized, and they have been only mildly pyritized. No economic minerals have been observed within the dikes. The probability is, therefore, that the mafic dikes were not subject to replacement by the ore-bearing solutions. In general wide seams of ore are associated with few dikes, narrow seams with many dikes. The fact that there are more dikes within the ore and the alteration zone at depth, particularly on the 5th level intermediate, than higher in the ore body, suggests that dikes may be plentiful below the 5th level. Whether or not abundant dikes below the 5th level would be accompanied by lean ore is uncertain.

RESULTS OF EXPLORATION

The surface holes (pls. 2, 4) drilled by Hoefling Brothers on the mineralized zone north of the mine intersected only sericite schist and pyrite, and disproved the existence of ore near the surface in that region. The logs of many of the underground holes are missing, but those that are extant, with the possible exception of hole 404, 4th level, disprove the existence of mining-grade ore in the walls to the east or west. No ore or altered rock has been observed south of the workings, and there seems little likelihood of any being discovered in that region. The ground below the workings has been explored only by short underground holes 420 and 421.

Diamond-drill hole T2 from the 2d level (pl. 3) intersected 45 feet of low-grade ore averaging nearly 4 percent zinc and 1 percent copper. There may be a substantial tonnage of this material present in the wall-rocks, but data are too meagre to warrant an estimate.

About 1,000 feet east of the Big Bend mine there is a siliceous gossan somewhat resembling that at the mine. Gold assays of samples of this gossan range from 25 cents to $2.21 to the ton. In June and July 1945 Hoefling Brothers trenched this gossan and explored the ground below with three shallow drill holes. Although mildly pyritized, baritized, silicified schist and greenstone were found, no ore or sericite schist was present.

AREAS FAVORABLE FOR EXPLORATION

Drill hole 311 (pl. 3) intersected sericite schist and massive pyrite in the hanging wall of the 3d level. Drill holes 406 and 404 (pls. 3 and 4) intersected sericite schist and zinc ore down the dip from the pyrite of drill hole 311. This mineralized zone in the hanging wall, which has not been explored below the 4th level, may be the tapering top of another ore body (pl. 2). Further exploration of this mineralized zone is desirable.

The downward extension of the main ore body beneath the 5th level also merits further exploration. As already pointed out, mineralized ground was discovered below the 5th level by holes 420 and 421. It is possible that ore may lie in the footwall block of the South fault below the lowest level, in contrast to the restriction of ore to the hanging-wall block in the mine workings.

GEOLOGY OF THE LILYAMA AND PIONEER MINES, EL DORADO COUNTY, CALIFORNIA *

By Manning W. Cox,** Donald C. Wyant,** and George R. Heyl **

OUTLINE OF REPORT

ILLUSTRATIONS

INTRODUCTION

The Lilyama and Pioneer copper mines are in El Dorado County, a short distance north of the South Fork of the American River, about 11 miles northwest of Placerville and 4¾ miles northwest of Coloma. The two properties are within 2,000 feet of each other, and are accessible by a short road leading northward from Highway 49, which crosses the southern portion of the Pioneer tract. Rail shipping points convenient to the mines are Placerville, El Dorado (Mud Springs), and Shingle Springs, all stations on the Placerville branch of the Southern Pacific Railroad.

The mines are in an area of moderate relief bordering Hastings Creek, a tributary of the South Fork of the American River. The Pioneer mine is located near the summit of a prominent conical hill rising about 350 feet above the creek. On its north side this hill is joined by a shallow saddle to a higher east-west ridge; the Lilyama mine penetrates the lower slopes of the southern flank of this ridge.

Little is known of the early history of the mines. After having lain idle for years, they were reopened in 1943 by Volo Associates (now Pioneer-Lilyama Mines) of Placerville, California. At that time some of the old workings were reconditioned, and since then, at the Lilyama mine, hundreds of feet of new workings have been driven. Mining at the Lilyama property has continued to the present time. Recent production of the Lilyama mine is given in table 1.

The Lilyama mine consists of four adits which connect with the laterals, and several small stopes. The adits with their lateral workings have a total length greater than 1,000 feet, are developed through a vertical range of 132 feet (pl. 5), but are not connected underground. Only the lowermost two of these, designated the Lower and Upper Tunnels, are in active use. One hundred and eighty feet from the mouth of the Lower Tunnel is a 15-foot winze, and in the Upper Tunnel, near its north end, is an 18-foot winze and a raise which at one time extended to the surface.

The Pioneer property includes four shafts and an adit; of these, only one shaft, 80 feet deep, and a short crosscut and contiguous stope at the base of the shaft were accessible for examination (pl. 6).

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Table 1. Recent production of the Lilyama mine.[1]

Period	Ore (tons)	Copper[2] (pounds)	Gold (ounces)	Silver (ounces)
1944	1,400	52,000	30	623
1945	3,120	96,000	80	990
1946	[3]	70,000	107	873
Totals[4]	4,520	218,000	217	2,486

[1] Minerals Yearbook, U. S. Bureau of Mines, 1943-46.
[2] Pounds of recovered metal.
[3] 214 tons of concentrates.
[4] Does not include small amount of ore produced during development work in 1943.

The exploration and mining activity at these properties presented an opportunity for the U. S. Geological Survey to examine the mines and study the ore deposits. In November 1943, G. R. Heyl and M. W. Cox mapped the accessible portions of the Lilyama mine and made a cursory examination of the surface geology. Four months later M. W. Cox and D. G. Wyant returned to map the surface geology of the areas adjacent to each mine, and to examine and map the accessible parts of the Pioneer mine and newly developed workings in the Lilyama mine. For permission to enter the properties and study the deposits the writers are indebted to Messrs. O. H. Griggs, F. V. Phillips, and T. S. Reeves of Volo Associates.

GENERAL GEOLOGY

The Lilyama and Pioneer mines are about 7 miles west of the Mother Lode, which extends northward from Placerville through Garden Valley and Georgetown. The copper deposits are developed along the west margin of a large granodiorite stock, more than 13 miles long, and, near the mines, about 2 miles wide. They are pyrometasomatic deposits in metamorphic rocks adjacent to the intrusive contact. The metamorphic rocks, which include hornfels, marble, and tactite, have been mapped by Lindgren and Turner [1] as belonging to the Calaveras formation (Carboniferous). The copper deposits are in roof pendants or large blocks of country rock included in the granodiorite, 50 to 1,000 feet from the edge of the stock.

In the vicinity of the mines the most widespread rock in the stock is a medium- to coarse-grained hornblende granodiorite. A lighter-colored facies of granodiorite, nearly devoid of mafic minerals, underlies a large area southeast of the mines, and is well exposed along Highway 49. Syenite porphyry similar in appearance to the lighter facies of granodiorite is present as a narrow dike intruding hornfels in the Lower Tunnel of the Lilyama mine. This adit also exposes an irregular dike of dark hornblende diorite which is penetrated by stringers of granodiorite. The granodiorite stock has a distinctive contact facies generally about a foot wide; it is a fine-grained, greenish-gray rock composed of quartz, clear plagioclase, epidote, and chlorite, and locally may contain calcite. At the mouth of the Upper Tunnel of the Lilyama mine a 20-foot width of this rock is present along the granodiorite contact.

[1] Lindgren, W., and Turner, H. W., U. S. Geol. Survey Geol. Atlas, Placerville folio (no. 3), 1894.

The most prevalent metamorphic rock near the mines is fine-grained hornfels, ranging in color from light gray green to black, and locally containing large biotite flakes. With a hand lens the minerals visible are quartz, biotite, chlorite, epidote, and possibly an amphibole. No bedding or other compositional layering is apparent in the hornfels.

Garnet quartzite with a fine-grained saccharoidal texture crops out directly above the Lilyama mine workings, but is not exposed underground. It has been derived from zones of arenaceous rocks in the original sedimentary sequence.

At the Pioneer mine coarsely crystalline white marble derived from bedded limestone is an important rock, forming a discontinuous belt trending slightly west of north, and dipping nearly vertical. Most of the marble is made up almost entirely of calcite, but near the north end of the area shown on plate 6 there is a small patch containing abundant wollastonite. No marble was observed at the Lilyama mine; however, about 200 feet northwest of the uppermost adit a thin layer of white jasperoid containing irregular masses of rust-colored chert probably represents a replaced bed of limestone.

The Lilyama deposits are close to the irregular margin of the granodiorite stock, but the Pioneer copper deposit is at least 1,000 feet from the exposed border of the intrusion. At both mines there is a suggestion of a pervading rectilinear pattern in the boundaries and distribution of the metamorphic rocks (pls. 5 and 6). This probably reflects the efficacy of prior-formed joints and similar structures that the invading magma followed at the time of intrusion. Because the mine openings are limited to a narrow vertical distance, it has not been possible to determine the downward extent of individual masses of metamorphic rock included in the granodiorite. The factors which determined their extent in two dimensions were probably the same as those which determined their size in the third. Therefore, it seems safe to estimate that the extent in depth of a certain block is of the same order of magnitude as its length or breadth. It is important to note, however, that the vertical range within the stock in which such blocks or pendants may be expected to be present is much greater than the vertical extent of any given mass of included metamorphic rock.

TACTITE BODIES

Tactite is present as irregular bodies in hornfels, garnet quartzite, and marble. These range from the size of a hen's egg to masses scores of feet wide. The larger bodies are shown on the accompanying maps (pls. 5 and 6).

Both coarsely crystalline and fine-grained tactite are present. In composition the tactite ranges from quartz-calcite-garnet rock through quartz-calcite-magnetite rock and garnet-magnetite rock to material made up almost entirely of magnetite. In many places other minerals are intergrown with these, and include a dark-green pyroxene or amphibole epidote, feldspar, chlorite pseudomorphic after amphibole, ilmenite, specular hematite, pyrite, and chalcopyrite. A small amount of bornite was observed at the Lilyama deposits, and ultra-violet light disclosed small spots of scheelite in the tactite of the Pioneer mine. The silicates, magnetite, and pyrite in many places occur as euhedral crystals; the others are present as anhedral masses or small grains. In most places the intergrown dark and light minerals of the tactite give it a mottled appearance. Banding is seldom observed.

Veinlets of quartz-feldspar, quartz-calcite-garnet, and quartz-calcite-sulphide cut the tactite bodies, and are particularly abundant in the Lilyama deposits. In a few places these veinlets extend into adjacent hornfels, marble, or granodiorite, in general following well-defined joints.

The larger tactite masses in the Lilyama mine are adjacent to granodiorite; coarse-grained tactite is seldom seen more than 20 feet from granodiorite, and in most exposures such tactite is limited to a width of 2 feet from the intrusive contact. In many portions of the Pioneer mine area, however, where granodiorite more intimately penetrates the metamorphic rocks as narrow dikes and apophyses, tactite, both coarse- and fine-grained, is more widespread.

Many tactite bodies are bounded on one or more sides by regular joints or minor faults. They are therefore somewhat angular masses, their contacts with the adjacent rocks being sharp. In the Lilyama area there is a prominent fault system, the member faults trending approximately east and dipping 42°-65° south, with apparent displacements, where measurable, of less than 5 feet. At several places in the mine, as in the first east lateral of the Lower Tunnel (pl. 6), tactite is localized along these faults, which together with related joints, probably served as channelways for the infiltrating metasomatic solutions. Tactite lying against these faults in places is slickensided, indicating that some movement took place along them after the formation of these bodies.

ORE BODIES

The ore bodies are those parts of the tactite that, across minable widths, contain appreciable amounts of chalcopyrite or bornite. These minerals and pyrite are present in the tactite as irregular masses and streaks, their deposition having apparently been controlled to a certain degree by persistent joints. Sulphides are most commonly associated with quartz-calcite-magnetite rock, and tactite with abundant magnetite and calcite generally contains enough intergrown sulphides to be classed as ore. In some tactite and contiguous hornfels, veinlets of sulphides follow joints; where these are closely spaced and present in sufficient quantity, the rock is mined as ore.

Locally, sulphides may make up as much as 30 percent of the volume of rock mined, but most of the ore contains a much smaller proportion of these minerals. Although small specimens may be obtained that are estimated to assay as high as 15 percent copper, the grade of ore across widths 3 feet or greater probably averages close to 2 percent copper at the Lilyama mine, and less at the Pioneer mine. Most of the ore bodies are small, and are therefore difficult to locate and expensive to mine.

Near the hill crest immediately east of the Lilyama mine, iron-stained tactite and hornfels crop out over an area about 240 feet long and 70 feet wide. In places the rock contains abundant magnetite and a few streaks of gossan, and these probably represent the outcrop of the ore bodies mined in the Upper Tunnel.

In general, weathering has been effective to depths of 40 feet or more, but there is very little evidence of supergene enrichment in the deposits. The uppermost adit of the Lilyama area (pl. 5) penetrates the hill 30 to 35 feet below its crest, and is driven through weathered granodiorite and hornfels that contain thin seams of malachite and chrysocolla.

The sulphides have been completely oxidized, and calcite has been leached from small pockets of tactite. The portal of the abandoned adit 17 feet below this is likewise in weathered rock, and for an additional 20 feet downslope the granodiorite has been thoroughly weathered. At the Pioneer mine, sulphides are partially oxidized to a depth of 40 feet in the accessible shaft.

The search for additional ore bodies should be limited to areas of contact-metamorphosed rock, and particular attention should be paid to the ground immediately adjacent to granodiorite contacts. Because magnetite is a common associate of the copper ores in these deposits, a detailed map of the magnetic anomalies of the area would probably prove useful as a prospecting aid.

NEWTON COPPER MINE, AMADOR COUNTY, CALIFORNIA *

By George R. Heyl ** and John H. Eric **

OUTLINE OF REPORT

ILLUSTRATIONS

ABSTRACT

The Newton copper mine is located about 6 miles west of Jackson in the lower foothills of the Sierra Nevada. The ore deposit is a steeply dipping lens of massive sulphides, chiefly pyrite and chalcopyrite, developed by replacement along a zone of structural disturbance—possibly an old fault line—in schists of low-rank metamorphism derived from volcanic rocks. The ore ranges in grade from 1.25 to 21 percent copper, has little zinc in it, a very minor amount of lead, and only very small amounts of gold and silver. If economic conditions remain favorable, the outlook for the mine is good, because the geological characteristics of the deposit indicate that the ore shoot continues downward on its established trend with no marked changes in tenor or size for an appreciable distance below the 550 level of the mine.

INTRODUCTION

The Newton copper mine lies in sec. 28, T. 6 N., R. 10 E., Mt. Diablo base and meridian. It is located at the hamlet and former post office of Ranlett (pl. 1) about 6 miles west of Jackson, along the main highway from Jackson to Ione.

The mine is at an altitude of about 600 feet, in the lower foothills of the Sierra Nevada, several miles from their western edge.

Mountain Spring Creek, a tributary of Sutter Creek, drains the area immediately adjacent to the mine.

During parts of 1943-45, the Newton mine and adjacent areas were mapped by geologists of the U. S. Geological Survey as part of its war-time program of investigations of the Foothill copper-zinc belt. During the fall of 1943, G. R. Heyl and M. W. Cox mapped the geology of the underground workings of the mine, which then contained seven levels.

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In this work use was made of a shaft survey by Mr. W. H. Ralph, who also determined the magnetic declination at the mine. In 1944 and 1945 two additional levels were developed, and they were mapped by the writers in the spring and summer of 1945; a survey connecting these levels with the higher levels was established by Mr. Francis Frederick of the Pacific Mining Company. A tenth level (not shown on the accompanying maps) was developed during 1946. Base maps of the workings, supplied by the Winston Copper Company and the Pacific Mining Company, with some modifications, have been used as a basis of the geologic maps.

Mr. Wayne Loel, president of the Winston Copper Company, very generously contributed the aerial photographs used by the writers in the surface mapping. J. H. Eric established plane-table control by which these pictures were adjusted.

It is a pleasure to express sincere thanks for the hearty cooperation given by the mine staff, and in particular by the late Mr. H. M. Lewers and by Mr. Harold Hanson. Dr. Olaf P. Jenkins of the State Division of Mines has kindly permitted us to include assay data on the mine taken from a report by Mr. A. H. Lawry. Mr. W. H. Ralph supplied the Allen mine drawing.

The descriptions of rocks and ores are based on field observations, as only a few thin-sections and no polished sections have been studied.

HISTORY AND PRODUCTION

The Newton mine was located early in 1863 by J. Newton of Jackson, and for the next 4 years, until April 1867 when operations ceased, the mine was worked vigorously. According to Browne,[1] during this early period most of the ore averaged 15 percent copper, and for each month in 1864 about 100 tons of ore averaging 16 percent copper was shipped from this property. Commercial records show that by the latter part of 1866, 3000 tons of ore had been shipped to San Francisco firms from the Newton mine, but a complete record of its production during the sixties is not known. The mine is said to have yielded high-grade ore to a depth of 200 feet. At greater depth the ore decreased in tenor, and failed to pay for shipment under conditions and prices which prevailed at the time.[2]

In 1886 the mine was acquired by the Newton Copper Company, and was reopened in 1887. During the next 13 years it was worked intermittently. In 1889 an 80-ton smelter was installed, and in 1899 an 80-ton water-jacket blast furnace was added to the surface plant. By 1900 the mine had been developed to the 400 level. In that year 3500 tons of 7 percent ore was mined, of which 3000 tons was heap roasted and smelted.[3] From 1901 until its recent period of activity, little or no mining was done.

In 1891 leaching of ore for cement copper was carried on, and this was continued by the Newton Copper Company until 1909.

The mine lay idle until late in 1942, when unwatering was begun by J. H. Lester. By the summer of 1943 the mine had been rehabilitated,

[1] Browne, J. R., Mineral resources of the States and Territories west of the Rocky Mountains for 1866, pp. 138-169, 1867.
———— Mineral resources of the States and Territories west of the Rocky Mountains for 1867, pp. 207-219, 1868.
[2] Aubury, L. E., The copper resources of California: California Min. Bur. Bull. 50, p. 33, 1908.
[3] Aubury, L. E., op. cit., pp. 222-224.

and mining was resumed by the Winston Copper Company, whose activities were confined chiefly to the mining of pillars and a block of supergene enriched ore in the upper part of the mine. In 1944 the property was sublet to the Pacific Mining Company, which has deepened the shaft and developed two levels (450 and 550, pl. 8) below the old workings; a lower level was developed during 1946. The production of cement copper from the mine water also was resumed.

In 1942 and 1943, the U. S. Bureau of Mines[4] put down 5 diamond-drill holes totaling 4,258 feet (fig. 2). Hole 1 intersected the 400 level (pl. 8). Hole 2 encountered ore just east of what is now the lower part of the shaft. Holes 3 and 5 showed ore at depth (pl. 10). Hole 4 is north of the ore body, and failed to intersect ore.

The production of the mine, insofar as it is known, is summarized in the following table:

Table 1. Production of the Newton mine.[1]

Period	Ore (tons)	Gold (fine ounces)	Silver (fine ounces)	Copper (pounds)	Lead (pounds)
1863-1908	33,000	[2]	[2]	–	[2]
1900	3,500	[2]	[2]	[3]450,000	[2]
1901	[2]	[2]	[2]	[3, 4]60,000	[2]
1902	[2]	[2]	[2]	[2]	[2]
1903	[2]	[2]	[2]	[4]15,000	[2]
1904	[2]	[2]	[2]	[4]140,000	[2]
1905	[2]	[2]	[2]	[4]10,000	[2]
1906	[2]	[2]	[2]	[4]8,648	[2]
1907	[2]	[2]	[2]	[4]5,300	[2]
1908	[2]	[2]	[2]	[4]1,909	[2]
1909	[2]	[2]	[2]	[4]1,023	[2]
1910-1911	[2]	[2]	[2]	[2]	[2]
1912	48	[2]	44	9,952	[2]
1913-1942	[2]	[2]	[2]	[2]	[2]
1943	3,538	24	1,481	[5]623,500	[5]2,000
1944	4,327	29	1,966	[5]474,000	------------
1945	14,875	133	12,119	[5]1,653,800	------------
1946	18,474	181	15,240	[5]2,008,000	------------
Totals	77,762	367	30,850	5,461,132	2,000

[1] Source of data: Bulletin 50, California Mining Bureau; personal communications from C. W. Merrill and A. L. Ransome, U. S. Bureau of Mines; and Minerals Yearbook, U. S. Bureau of Mines, 1943-46.
[2] No production reported.
[3] Estimate by writers.
[4] Produced by precipitation.
[5] Pounds recovered metal.

GENERAL GEOLOGY

The Newton mine is within a thick series of schists and greenstone of low-rank metamorphism derived from volcanic rocks (pl. 7); these rocks were mapped by Turner[5] as amphibolite schist of undesignated age, but the writers tentatively correlate them with the Jurassic Amador group described by Taliaferro.[6]

In general the rocks dip steeply eastward; in places some beds are vertical. Graded bedding, where observed, suggests that these rocks lie on the western, overturned limb of a major anticline; if this suggestion is correct, the rocks become progressively older toward the east.

[4] West belt copper-zinc mines, Amador and Calaveras Counties, California: U. S. Bur. Mines War Minerals Rept. 103, p. 5, 1943.
[5] Turner, H. W., U. S. Geol. Survey Geol. Atlas, Jackson folio (no. 11), 1894.
[6] Taliaferro, N. L., Geologic history and correlation of the Jurassic of southwestern Oregon and California: Geol. Soc. America Bull., vol. 53, 1942.

Stratigraphic section along Mountain Spring Creek

	Thickness in feet (approx.)	
Mariposa slate (Jm, pl. 7). Chiefly dark blue-gray slate, weathering brown, olive-brown, or silvery gray, with thin intercalations of volcanic rocks in its lower portion.		
Amador (?) group		
Mountain Spring volcanics (Jam, pl. 7). Pale-green slaty tuffs, medium- to fine-grained, weathering brown, with thin intercalations of dark blue-gray slate. A minor amount of sericite is present in some of the tuffs. The uppermost zone consists of about 3 feet of volcanic breccia, pale greenish-gray, weathering drab greenish-brown, containing darker-green fragments as much as half an inch in size; the rock contains sparse, finely disseminated pyrite, and white carbonate that is probably introduced	75	
Dark blue-gray slate (Jams, pl. 7), weathering pale brown	40	
Feldspathic chlorite schist, in places with abundant epidote knots; some zones carry visible quartz. Probably derived from a pyroclastic rock	175	
Medium-green feldspathic chlorite schist, with small dark greenish-black amphibole crystals, probably uralite, scattered through it. The rock has a fairly coarse fragmental texture, and includes some felsic fragments up to as much as 6 inches long. Probably derived from a volcanic breccia	40	
Feldspathic chlorite schist, with a thin zone near the base carrying white sericitic fragments. Probably derived from a pyroclastic rock	230	
		560
Dufrene slate (Jad, pl. 7). Dark blue-gray slate, weathering light-brown	135	
Fine-grained gray sandstone, weathering brown	4	
Dark blue-gray slate, weathering light-brown	95	
Dark blue-gray slate, with thin interbeds and lenses of fine-grained gray sandstone	80	
Dark blue-gray slate, with intercalations of conglomerate with argillaceous matrix. The pebbles in the conglomerate zones are dark-gray fine-grained sandstone, generally an inch or less in diameter, and are stretched parallel to lineation, which is nearly down the dip of the beds	68	
Dark blue-gray slate, weathering light-brown	94	
Fine-grained gray sandstone, with intercalations of dark blue-gray slate	20	
Dark blue-gray slate, weathering light-brown, with a few beds of fine-grained sandstone and tuffaceous or arkosic sandstone	120	
Dark blue-gray slate, with some interbedded fine-grained sandstone	55	
Green chloritic, feldspathic schist (Jade, pl. 7), with amphibole crystals	14	
Dark blue-gray slate, weathering light-brown, with intercalations of pale-green fine-grained chloritic tuff	60	
		745
Newton mine volcanics (Jan, pl. 7). Pale-green chlorite schist, much of it feldspathic, and, less commonly, sericitic. Present throughout this zone are euhedral crystals of dark-green amphibole (probably uralite), and, near the base, epidote. In places the fragmental texture is quite evident	250	
Pale-green chlorite schist and chlorite-epidote schist, some of it feldspathic. Visible crystals of amphibole are not common in this zone	125	
Blue-gray slate (Jans, pl. 7), weathering pale gray to pale brown*	12	
Pale-green chlorite schist and chlorite-epidote schist, some of it feldspathic. Visible crystals of amphibole are not common in this zone	180	
Pale-green fine-grained bedded tuff, weathering brown	100	
Fine-grained green chlorite-epidote-amphibolite schist, weathering brown. This rock forms the footwall of the Newton mine mineralized zone	85	
		752
Total thickness of section		2057

* Not exposed in section, but occurs elsewhere in the area.

Capping the higher hills in the neighborhood of the Newton mine, and forming extensive mesas in the southeast portion of the map-area, is a sequence of coarse andesitic agglomerate, gravel, and ashy sand, which Turner considers to be of Neocene age.[7] These beds have a very gentle westward dip, but show no evidence of deformation. Their base is an unconformable surface which truncates the older rocks.

STRATIGRAPHY

The stratigraphic section exposed in the western part of the area, from the Mariposa slate eastward along Mountain Spring Creek to the Newton mine is given on page 52.

The Mountain Spring volcanics are named from Mountain Spring Creek along which these rocks crop out; the Dufrene slate is named from the Dufrene ranch west of the Newton mine; and the Newton mine volcanics are named from the mine itself. In the absence of fossil evidence, wider regional studies will be necessary to determine definitely whether the Dufrene slate and the Mountain Springs volcanics should be considered as uppermost Amador or as part of the Mariposa slate.

The measured section given above, in general, is steeply dipping to the east. The relation of these beds to the Mariposa slate to the west suggests that the section is overturned, and is on the west limb of an overturned anticline or its faulted equivalent.

Eastward from the Newton mine, chlorite-epidote-amphibolite schist crops out in a belt about 775 feet wide; to the east of this belt is 40 to 50 feet of fine-grained chloritic tuff, which marks the eastern boundary of the Newton mine volcanics. Near the mine this unit is made up largely of pyroclastic rocks; farther northward, however, especially along Sutter Creek where there are features resembling distorted pillows, it seems likely that flows are also present. In the northern part of the area a wedge-shaped mass of metafelsite of undetermined thickness forms a distinct member within this volcanic unit.

East of the Newton mine volcanics a sequence of undetermined thickness is designated Sunnybrook volcanics, from Sunnybrook Crossing at the east edge of the map-area. This unit consists dominantly of gray felsic rocks, including bedded feldspathic tuff and felsitic quartz-bearing tuff of rhyolitic composition. Within the felsitic rocks is a zone, approximately 400 feet thick, of dark-green chlorite-uralite schist, probably derived from pyroclastics. The Sunnybrook volcanics are at least 1500 feet thick; because of the paucity of outcrops, no detailed stratigraphic section is given.

INTRUSIVE ROCKS

Three types of rock that are probably intrusive occur within the map-area (pl. 7), but none of them is found close to the Newton mine. Dark-green medium-grained massive pyroxenite, with minor peridotite and serpentine, is found along Sutter Creek; the absence of foliation may indicate an age younger than the regional metamorphism. Three small isolated lenses of schistose quartz porphyry crop out, two in the northeastern part of the map-area and one in the central part. In the eastern part of the area a long sill-like body of sericitized, moderately schistose, pale-gray felsite with a few visible feldspar crystals, has been mapped.

[7] Turner, H. W., op. cit., p. 5.

The configuration of the walls and the pattern of this body are similar to that of the intrusive quartz porphyry of the Penn mine area,[8] about 8 miles to the south.

STRUCTURE

Bedding observed within the map-area generally dips steeply eastward. A few vertical dips are present, and one as low as 45° is recorded. No westward dips of bedding were observed. Similarly, the foliation, in general, dips eastward at high angles, or is vertical. No simple generalization can be made about the relation between foliation and bedding; in places they are essentially parallel, in other places, one is appreciably steeper than the other.

In the south-central part of the area is a noteworthy exception to the general east-dipping attitude of foliation. There, trending with the strike, is a narrow belt along which west-dipping foliation is not uncommon. It is evident just north of the small Tertiary andesite outlier near the south edge of the map (pl. 7), and it extends northwestward through the Newton mine at least as far as 1500 feet north of the state highway. Aerial photographs bring out a small but nevertheless persistent difference in the grain of country east and west of this zone, a result of the southward convergence of strike directions at a very acute angle.

This zone of structural disturbance is probably significant in the origin of the Newton ore deposit. It may represent a line of faulting or strong shearing formed early in the structural history of the region. Whether it marks a zone of stretching and displacement in the overturned limb of a major anticline whose axis lies farther eastward, or whether it represents a disturbed zone along the axial plane of an isoclinal fold or its faulted equivalent, is not known, but the lack of repetition of the lithologic sequence across the strike suggests that the former is more likely.

Lineation on foliation or on bedding can be observed in most parts of the area, and plunges northward at angles ranging from 50° to 80°. The northward rake of the Newton sulphide body is parallel to the strong lineation developed in the wallrocks of the ore deposit.

THE ORE DEPOSIT

The ore deposit is a steeply dipping lens of pyrite and chalcopyrite developed by replacement along a zone that in general is parallel to schistosity in the country rock. In most places the sulphide vein dips 62° to 68° eastward, but because of the displacement caused by a reverse strike fault between the 150 and 200 levels of the mine, the over-all dip of the vein in the vicinity of the shaft is approximately 70° (section A-A′, pl. 9).

The ore body has a maximum strike length of 460 feet (pl. 8), and has been mined through a length down-dip of about 600 feet. Drilling has proved that the ore extends more than 800 feet down the dip from the surface. The body rakes northward with a pitch angle [9] close to 77° and a plunge angle [10] varying from 62° to 65°. The known pitch length is about 900 feet. The ore is generally 3 to 6 feet thick, and its maximum observed thickness is 8 feet.

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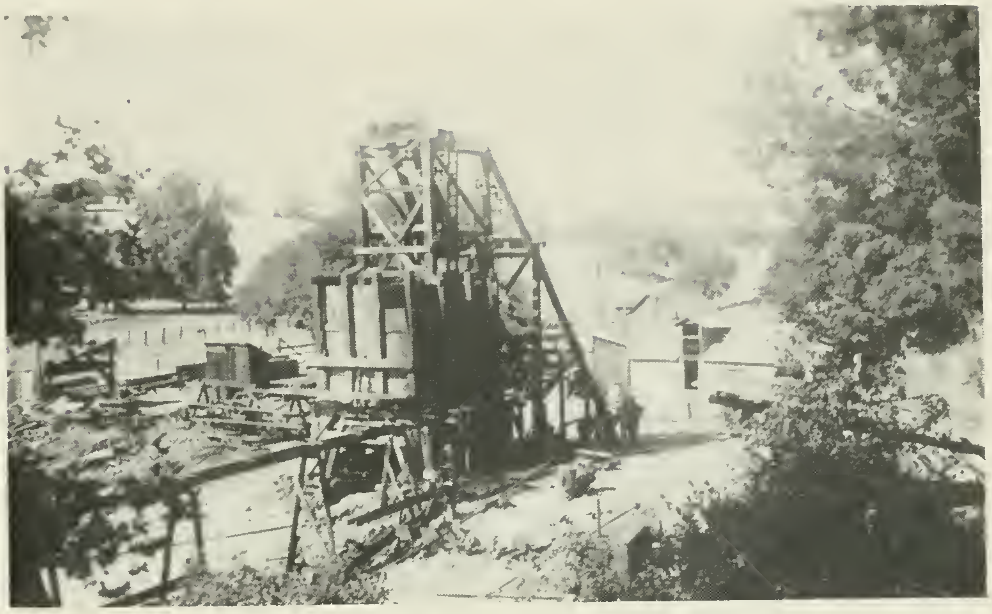
[8] See pp. 69-70.

[9] Pitch of an ore body, as here used, is defined as the angle between its axis and the strike of the vein, measured in the plane of the vein.

[10] Plunge of an ore body, as here used, is defined as the vertical angle between a horizontal plane and the line of maximum elongation of the body.



A, VIEW OF NEWTON MINE FROM SOUTH

B, VIEW OF NEWTON MINE FROM NORTHWEST

The ore is a fine-grained intimate mixture of pyrite and chalcopyrite. Appreciable amounts of chalcocite were present in the upper hundred feet of ore, but enrichment by chalcocite extended deeper adjacent to faults, in places to a vertical depth of 160 feet or more. On the 400 and 450 levels, in the northern part of the ore body near the footwall, small amounts of dark-gray fine-grained sphalerite are present as narrow layers within the other sulphides. Production figures show that a minor amount of lead is present, but no lead minerals were recognized megascopically. Gangue minerals occur only in small quantities, and include quartz, calcite, and sericite.

Excepting the supergene enriched ore, much of which assayed between 11 and 16 percent copper, the grade of ore probably averages close to 6 percent copper (pl. 11). Locally, however, it not uncommonly runs as high as 9 to 12 percent copper, and in exceptional cases assays of ore from the deeper parts of the mine have run 21 percent copper. The gold content of the ore is so low as to have little economic importance; where sphalerite is present the ore may contain as much as 0.5 percent zinc.

The south extension of the vein on the 400 level is marked by a 1- to 3-foot width of red hematitic jasper and gray siliceous rock, which include thin lenses of sulphides similar to those of the ore. The schist adjacent to this rock is silicified and epidotized, and locally the altered rock as well as the jasper may contain appreciable white carbonate (calcite, $N_0 = 1.666$). Similar relations are also evident near the south end of the ore body on the 150, 300, 350, 450, and 550 levels. At the north end of the vein similar silicified and epidotized rock is usually present, though jasper has been observed only as a few thin streaks a fraction of an inch wide. Locally, tiny drag folds in schistosity, and shear planes are developed along the extensions of the ore zone; these features suggest that the ore was deposited along an old fault surface or within a fault zone, and that the gray siliceous rock and jasper may represent a silicified gouge.

Along most of its length the footwall of the ore body is intensely pyritized, and generally contains a small amount of sericite and quartz. In some places, as on the 350 level northward from the shaft, the footwall rock consists almost entirely of pyrite. The ore body consistently has a greater strike length than does the pyritized footwall (pls. 8 and 10); the economic limits of the ore, however, correspond roughly to the limits of the footwall pyrite. Some assays of the pyritized footwall are given on plate 11.

The hanging wall of the ore is chlorite schist which megascopically shows little or no effect of alteration except in the upper part of the mine, from about the 100 level to the surface, where it has been thoroughly kaolinized, apparently by descending acid waters.

Structure of the Ore Body. At several places in the mine there are sharp local folds or rolls in the ore, having amplitudes and wave lengths ranging from 1 to 10 feet. One of these folds is near the north end of the 250 level, another can be seen in the small stope near the south end of the 300 level, and a third is exposed in the shaft about 15 to 20 feet above the 550 level. No brecciation is evident in the ore in these folds, and it therefore seems most probable that they represent preexisting folds replaced by ore.

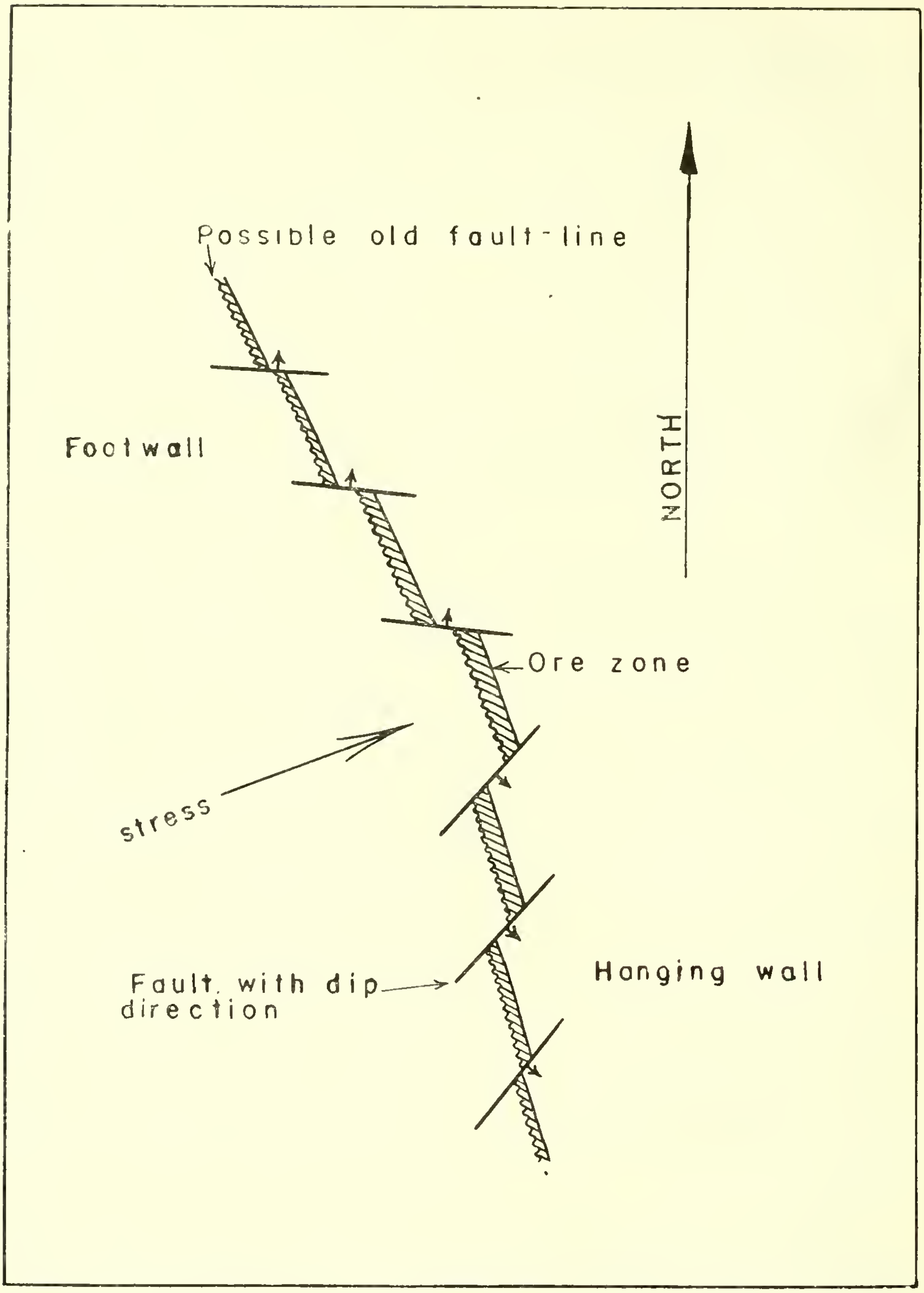


Fig. 1. Diagram showing suggested origin of fault pattern at the Newton mine, Amador County, California.

One of the most striking structural features of this deposit is the presence of a system of cross-faults that show apparent strike-slip displacements of as much as 20 feet (pls. 8, 9, and 10). The faults are younger than the ore because they displace ore, they locally contain drag ore caught between their surfaces, and the ore in many places shows considerable drag adjacent to the faults. Slickensides, where observed on these faults, have a low pitch, suggesting in these cases at least, that the strike-slip component of movement was appreciably greater than the dip-slip component. These cross-faults fall into a significant pattern; in general, those in the northern portion of the ore body have a northwesterly strike and a northward dip, and those in the southern portion have a northeasterly strike and a southward dip. This pattern strongly suggests that the faults were developed by a transverse stress or cross-buckle which resulted in the displacement of the central part of the ore lens farther eastward than either end (see fig. 1).

A prominent post-ore strike fault, which can be seen on the 200 level, where it is a fault zone, and in the shaft below the 150 level (pls. 8, 9, and 10), probably developed as a compensating structure related to the stress that developed the cross-faulting; it is therefore probably of approximately the same age. This reverse fault dips 55° to 60° westward, and the net slip, as indicated by slickensides, is essentially parallel to the dip.

In general, the pyritized rock of the footwall retains the structure of the replaced rock, and shows in addition to a well-developed parting parallel to the regional schistosity, a strongly developed linear element that plunges from 55° to 85° northward. This lineation may be the intersection of the parting parallel to the regional schistosity and a cross-parting—possibly a shear cleavage—that is developed at angles of 60° to 120° to the schistosity. However, the lineation is present in many parts of the pyritized footwall (and more rarely in the nonpyritized footwall or in the hanging wall) where no cross-parting is evident. The fact that the general trend of this lineation is parallel to the steep northward plunge of the ore body (pl. 10), suggests that either these linear features have a common origin, or the rake of the ore body has been controlled by the linear structure. In a few places in the mine, as for instance 50 feet north of the crosscut on the 250 level, the lineation is evident within the ore itself.

Also present in the wallrocks of the ore, and most commonly in the pyritized footwall, are minute crenulations whose axes are nearly horizontal and approximately parallel to schistosity, and small tension fissures, as much as an eighth of an inch wide, which strike nearly parallel to the schistosity and dip gently eastward or westward. In some places the crenulations lie at intersections of the schistosity and the tension fissures.

At several places along the hanging-wall surface of the ore, small folds measured in inches or fractions of an inch are developed in the schistosity of the country rock. These folds apparently were developed by drag resulting from minor movement on the hanging-wall contact, because they are most commonly associated with minor warps on this surface.

Origin of the Ore Deposit. The Newton ore deposit was probably developed by replacement along a strike fault zone in schist that is located on the western, overturned limb of an anticline, a likely locus

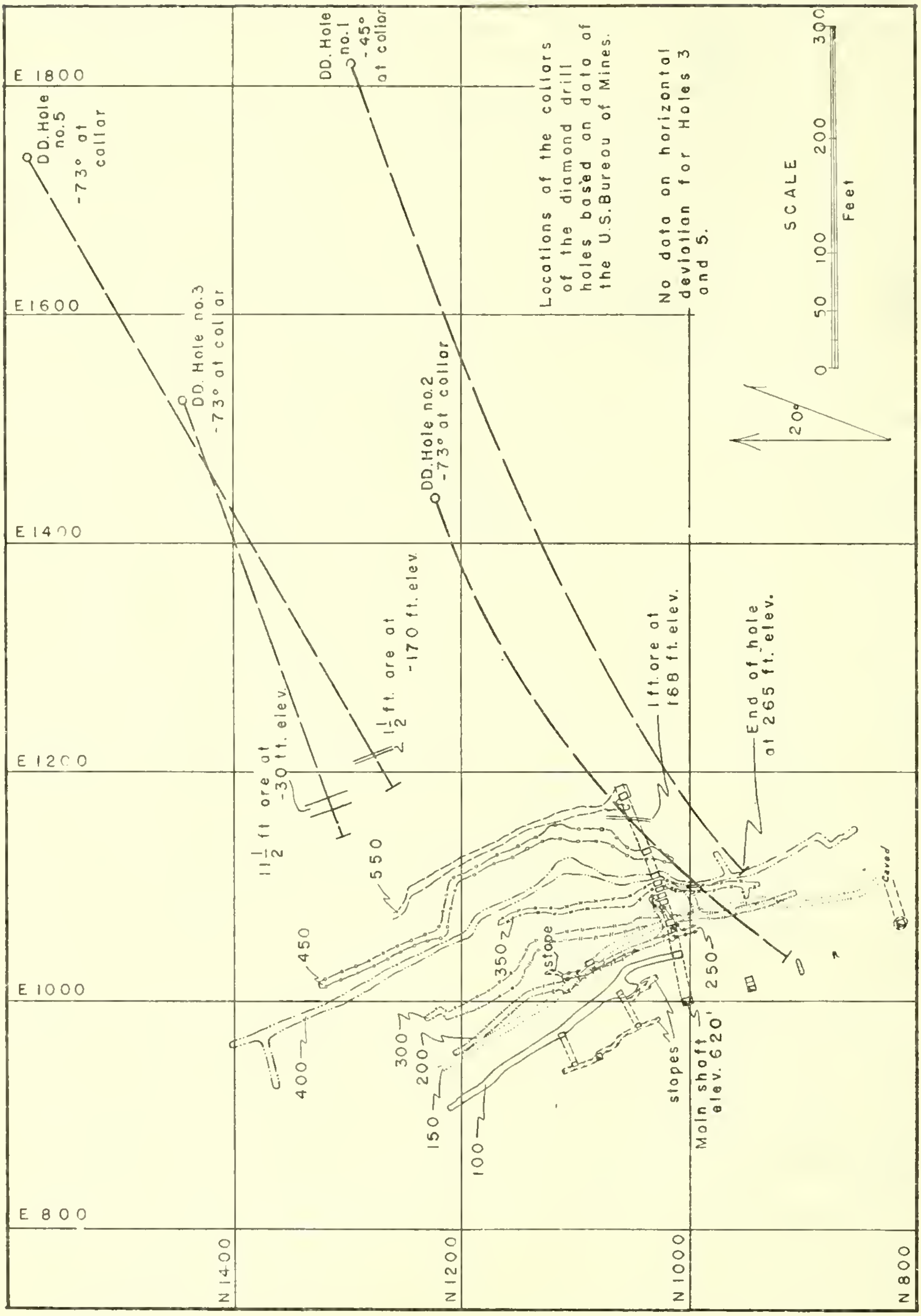


FIG. 2. Diamond-drill holes at the Newton mine, Amador County, California.

of failure resulting from stresses that produced the Nevadan orogeny. This fault zone has been inferred chiefly from the small but systematic difference in strike direction on either side of the zone, and from the presence of drag folds, minute shear planes, and irregularities in the attitudes of schistosity along the zone. The localization of ore as an elongate lens within this zone is possibly a result of a local transverse stress or cross-buckle, which developed a cross-parting—possibly a shear cleavage in origin—in the schists and otherwise opened up a limited zone, or a steeply inclined chimney, especially favorable to the circulation of hydrothermal solutions that caused rock alteration and replacement by sulphides. The pattern of cross-faulting in the mine (pl. 8 and fig. 1) suggests that this transverse stress was still effective, or was renewed, after the deposition of ore.

OTHER MINES IN THE AREA

About three-quarters of a mile northeastward from the Newton mine, is an inactive mine known as the Allen or the Hayward. It is reported to consist of four levels that turn off a 70° inclined shaft at 165, 250, 370, and 490 feet (pl. 13). The mine is located in a sill-like body of moderately schistose, sericitized felsite (pl. 7). The property is owned by the Allen Estate Company of Sutter Creek, California.

The underground workings are inaccessible, but the material on the mine dump gives some clues about the underground geology. Much of the dump material is pale-gray or greenish-gray felsite, mildly sericitized and moderately schistose, in many cases with strong lineation developed on the folia. A large amount of coarse- and medium-grained pyrite, having a relatively small amount of interstitial quartz and sericite, is present; in some specimens lineation can be discerned. Much less abundant are chunks of massive sulphides, chiefly pyrite with lesser amounts of chalcopyrite and sphalerite. Fragments of milky quartz, in some cases with pyrite, are not uncommon.

A. P. Busey, Jr., who examined the mine during World War I, reports that copper and zinc sulphides were present as narrow stringers within heavily pyritized rock, which formed the greater part of the mine faces he sampled.[11] Some idea as to tenor of material in the mine can be obtained from the assay data on plate 9; the information on this map is compiled from the reports of the mine foreman.

In the northwestern part of the map-area, about 500 feet south of Sutter Creek, is a fairly shallow inclined shaft sunk in pyritized sericite schist. No copper minerals or copper staining were observed at this locality. A specimen of pyritized schist, partly oxidized, was collected from the wall of the shaft about 15 feet below the collar; it was assayed for gold and found to contain 0.03 of an ounce per ton.[12]

OUTLOOK

The geologic characteristics of the ore body at the Newton mine, and particularly its width, tenor, and type of wallrock on the 550 and adjacent levels, suggest that the bottom of the sulphide lens lies considerably below that portion of the mine. This conclusion is borne out by diamond-drill holes, which indicate that the ore body extends at least

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[11] Busey, A. P., Jr., Personal communication.
[12] Loel, Wayne, Personal communication.

300 feet farther down-dip below the 550 level. Therefore, if economic conditions remain favorable, the outlook for the mine is good, because the geologic characteristics of the deposit indicate that the ore shoot continues downward on its established trend with no marked changes in tenor or size for an appreciable distance below the 550 level of the mine.

The narrow belt of alteration lying 1000-1600 feet northwest of the Newton shaft is a zone of strong silicification, with sparse pyrite scattered through it. Though in many places stained with iron oxides, little favorable gossan was observed within it, and its general appearance is not particularly encouraging to the prospector.

PENN ZINC-COPPER MINE, CALAVERAS COUNTY, CALIFORNIA *

By George R. Heyl **, Manning W. Cox **, and John H. Eric **

OUTLINE OF REPORT

ILLUSTRATIONS

* Published by permission of the Director, Geological Survey, U. S. Department of the Interior. Manuscript submitted for publication May 19, 1948.

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ABSTRACT

The Penn copper-zinc deposits in Calaveras County, California, are in slightly metamorphosed Jurassic volcanic rocks and intrusive quartz porphyry. Bedding, schistosity, and cleavage strike northwest and dip steeply northeastward. Two main types of faults are present: high-angle schistosity faults, and younger low-angle reverse faults. There are six main alteration zones, in which rocks have been sericitized, silicified, and pyritized.

The ore bodies are sulphide replacement deposits either at contacts of alteration zones, or along faults within these zones. The ore bodies are steeply pitching lenses. Their pitch length ranges from 150 to 1,000 feet; breadth, from 100 to 400 feet; width, from 4 to 30 feet. The ore is a mixture of pyrite, sphalerite, chalcopyrite, and a little bornite, tetrahedrite, and galena. Gangue minerals are barite, calcite, and quartz.

The Penn mine was first opened in 1861. Recorded production to the end of 1946 amounted to over 850,000 tons of ore, which yielded over 79 million pounds of copper, and also appreciable amounts of gold and silver. Zinc was not recovered from the ore until recently. Over 12 million pounds of zinc was produced from December 1943 to the end of 1946 from ore that averaged over 7½ percent zinc.

It seems likely that a well-planned and comprehensive exploration program at this mine and its immediate vicinity might uncover additional reserves. Such reserves, together with those known to exist in the mine, make the Penn mine one of the most promising in the Foothill belt.

INTRODUCTION

The Penn mine is in northwestern Calaveras County, California (pl. 1); however, the area studied (pl. 15) extends across the Mokelumne River into Amador County, and lies in secs. 3 and 4, T. 4 N., R. 10 E., and sec. 33, T. 5 N., R. 10 E., Mount Diablo base and meridian.

The area is traversed by gravel roads connecting with a surfaced road at Campo Seco, a mile to the east. Valley Springs, about 3½ miles southeast of the mine, is the closest rail shipping point.

The area is at an altitude of 200 to 450 feet in the low foothills of the Sierra Nevada, close to the eastern edge of the San Joaquin Valley. Maximum local relief within the area is about 270 feet. The higher hills are capped by flat-lying Tertiary gravel; the hill slopes below the gravel are commonly steep and locally precipitous.

The Mokelumne River, a trunk stream of the western slope of the Sierra Nevada, flows through the area from northeast to southwest and provides an ample supply of water for the mine. East of the area the river flows through a canyon but to the west it is in a graded valley with a narrow floodplain. The chief tributaries are Oregon Gulch, Mine Run, and Hinckley Run, intermittent streams in steep-sided valleys. In many places the upper reaches of these tributaries and the higher hill slopes are covered with gravel washed from the Tertiary beds by hydraulic mining.

The Penn mine is owned by the Penn Mining Company. It consists of four patented claims—the Satellite, Little Satellite, Campo Seco, and Hecla—and, adjoining these claims to the east and west, mill sites, a smelter site, and other lands held in fee simple.

Southeast of the Penn mine lies the Constellation or Borger group of three patented claims owned by the Constellation Mining Company. The Jean group of claims, which covers part of the area east of the Penn mine, is held by location by L. W. Thayer of San Francisco, who also owns the mineral rights to the land north of and flanking the Hecla claim. North of the Jean claims and east of the Penn mine is an area owned by the heirs and assigns of James Gallagher. A wedge-shaped plot east of the Thayer property and north of the Penn Mining Company land is owned by the Pacific Gas & Electric Company. The Amador County portion of the area is held in fee simple by L. W. Thayer, by the Penn Mining Company, and by H. G. Kreth.

The Penn mine workings extend for a distance of three-quarters of a mile and to a depth of 3,300 feet; in 1944 only a small part of these workings was accessible. The workings total about 55,000 feet, of which 42,000 feet is drifts and crosscuts and 13,000 feet is shafts and raises, as shown in plan on plate 14. The accessible parts are shown on plates 18, 19, 23, and 24.

For convenience the portions of the mine near the two accessible shafts are designated No. 2 shaft area and No. 3 shaft area respectively.

The Constellation group of claims is explored by the 400-foot vertical Borger shaft with lateral workings at four levels, and by a 45-foot shaft. These workings were inaccessible until early 1947, when they were unwatered and examined by the operators of the Penn mine.

The other properties are explored only by shallow shafts and short adits, apparently excavated for prospecting or assessment work.

The copper and zinc deposits of the Penn mine area were studied by the U. S. Geological Survey during 1942-45, as part of a wartime program of investigations of the Foothill copper-zinc belt. Field work was directed by G. R. Heyl, assisted at various times by G. L. Quick, J. B. Hadley, M. W. Cox, M. H. Staatz, D. G. Wyant, and J. H. Eric.

Areal mapping at the Penn mine was begun in November 1942 by Heyl, aided at first by Quick, and later by Hadley. Late in 1943 mapping was resumed and continued intermittently until November 1944 by Heyl, Cox, and Eric. A triangulation system was established by Staatz, Cox, Wyant, and Heyl in order to tie together the plane-table surveys. Control in the southernmost portion of the area was established by a transit traverse run by Cox and Eric.

Underground workings were mapped by Heyl, Cox, Eric, Staatz, Wyant, and Hadley during the period December 1943 to February 1945, as rapidly as rehabilitation of the mine permitted. Data for inaccessible workings have been obtained from a map of the Penn Mining Company, from a report made by Kruttschnitt,[1] in 1926, and from published sources.

The descriptions of rocks and ores are based on field observations as only a few thin-sections and no polished sections have been studied.

The authors wish to acknowledge the many courtesies and valued aid extended to them by the Penn Mining Company, by the Eagle Shawmut

[1] Kruttschnitt, Julius, Jr., Private report to American Smelting & Refining Co., 1926.

mine, and by Mr. L. W. Thayer. Messrs. C. W. Merrill and A. L. Ransome of the U. S. Bureau of Mines kindly made available to them information relating to the production of the mine.

HISTORY AND PRODUCTION

In the summer of 1861 three copper deposits were discovered near Campo Seco, and named the Campo Seco, Lancha Plana, and Copper Hill claims.[2] The Lancha Plana is the present Satellite claim and comprises No. 2 shaft workings; the Campo Seco is still known by that name and comprises No. 3 shaft workings; and the Copper Hill is the present Hecla claim on which the No. 5 shaft is located.

The period 1861 to 1867 was one of great activity, which was ended by a fall in the price of copper, and a rise in cost of operation. During this interval the three claims were operated as separate properties and no ore was shipped that ran less than 15 percent copper. Commercial records, which may not be complete, show that by the latter part of 1866 the following tonnage of ore had been shipped to San Francisco:[3] Campo Seco, 1,300 tons; Lancha Plana, 250 tons; Copper Hill, 1,500 tons; total, 3,050 tons.

In November 1865 a Welsh-type furnace was erected at a cost of $30,000. It had a smelting capacity of 8 tons and produced a 35-percent copper matte. The ore smelted ranged from 6 to 10 percent copper, and contained an average of 40 percent iron and 45 percent sulphur.[4]

In 1883 the Satellite mine was reopened by H. D. Ranlett,[5] and a tunnel was driven to shaft No. 1 (pls. 15 and 16). About three years later the property was sold to the San Francisco Copper Company.

About 1887 the Penn Chemical Company, predecessor of the Penn Mining Company, acquired the Campo Seco claim, and in 1888 removed the water from the mine and began operations. Later the same company bought the Satellite and Hecla claims, and adjoining property, which were merged into an operating unit known as the Penn mine. From September 1899 to April 1919 a smelter producing blister copper was operated continuously; it was closed in 1919 because of the unfavorable copper market that followed World War I.[6] During this period no attempt was made to recover zinc. From the smelter operation, gross returns, including gold and silver, were $7,362,562, and dividends amounted to $3,007,888.[7]

The Penn Mining Company continued underground development until March 1921, and the mine was kept pumped until June 1926. Early in 1926 J. Kruttschnitt, Jr., sampled the mine for the American Smelting & Refining Company.

In 1928 the Mateo Mining Company leased the mine and unwatered shaft No. 2 to the 700 level; only a small amount of ore was mined before operations ceased. A similarly short-lived project was undertaken in 1937 by the Penn Copper & Zinc Mining Company.

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[2] Browne, J. R., Mineral resources of the States and Territories west of the Rocky Mountains, for 1866, pp. 146-147, 1867.

[3] Browne, J. R., op. cit. p. 167.

[4] Browne, J. R., Report on the mineral resources of the States and Territories west of the Rocky Mountains, for 1867, pp. 207-219, 1868.

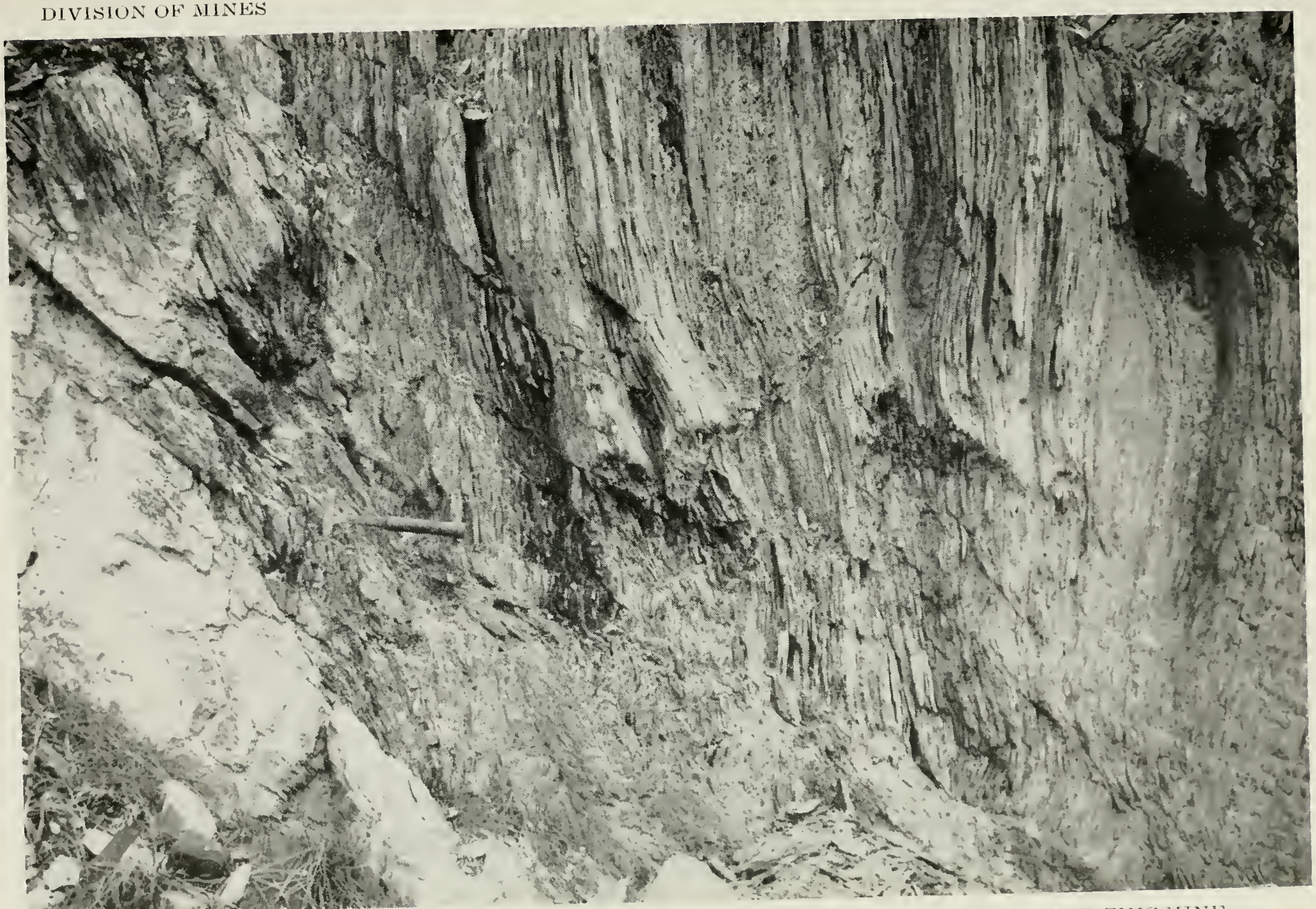
[5] Aubury, L. E., The copper resources of California: California Min. Bur. Bull. 50, p. 239, 1908.

[6] Julihn, C. E., and Horton, F. W., Mines of the southern Mother Lode region, pt. 1, Calaveras County: U. S. Bur. Mines Bull. 413, p. 112, 1938.

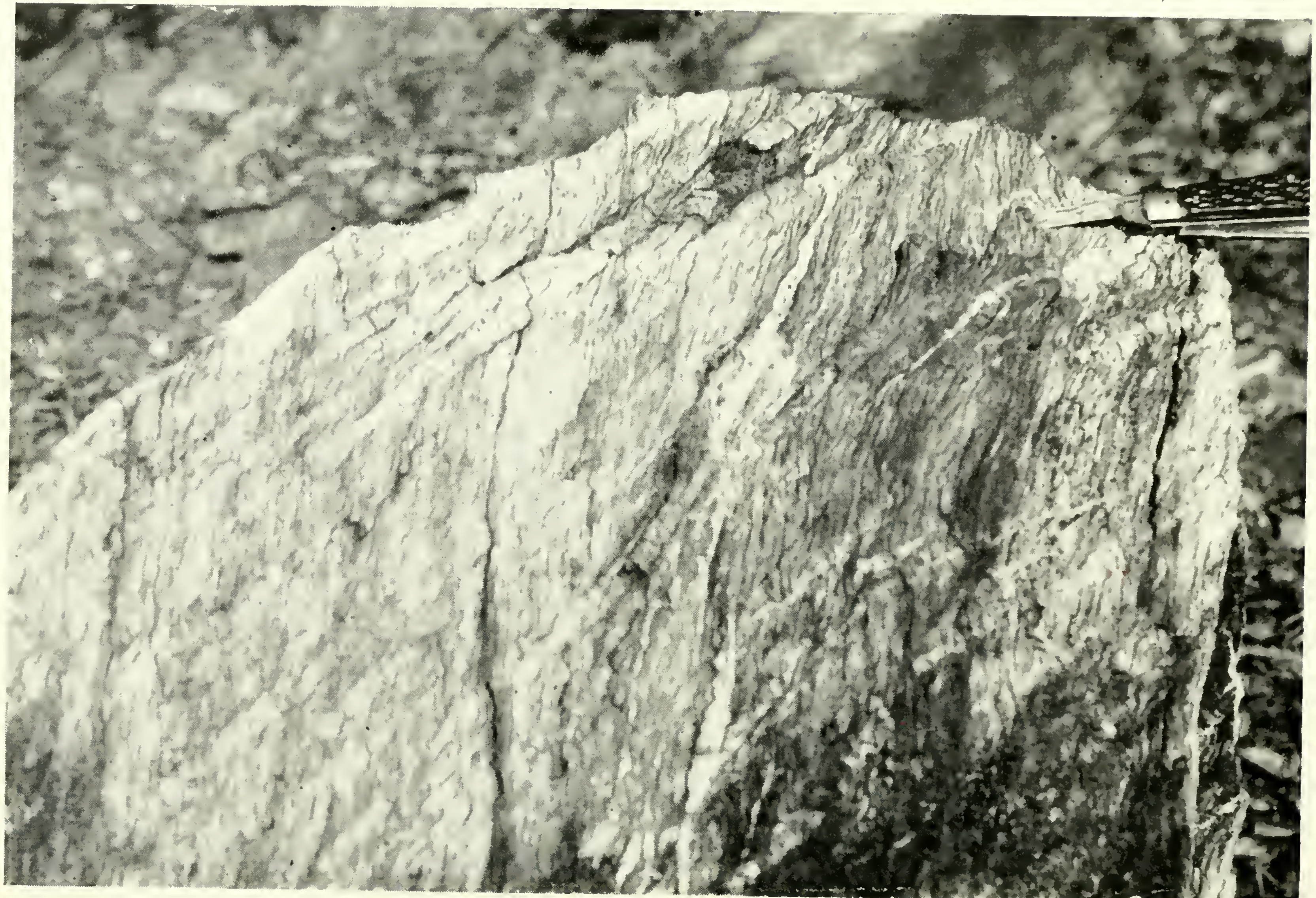
[7] Argall, G. O., Personal communication.

VIEW TOWARD THE EAST SHOWING NO. 2 SHAFT HEADFRAME OF PENN COPPER-ZINC MINE
Outcrops at skyline, left, West alteration zone ; pre-Tertiary unconformity at top of hill beyond headframe ; mill used in 1928 and 1937.

VIEW SOUTH TOWARD SATELLITE FAULT AT CAVED PORTAL OF PENN TUNNEL
Fault zone about 5 feet wide; 4-foot quartz vein below fault; gossan of ore body 1 below quartz vein.



DEFORMATION IN BORGER ALTERATION ZONE AT BORGER SHAFT IN PENN COPPER-ZINC MINE
Looking north toward small scarp; zone of echelon east-dipping reverse faults cuts sericite schist; there are a few complementary west-dipping reverse faults.



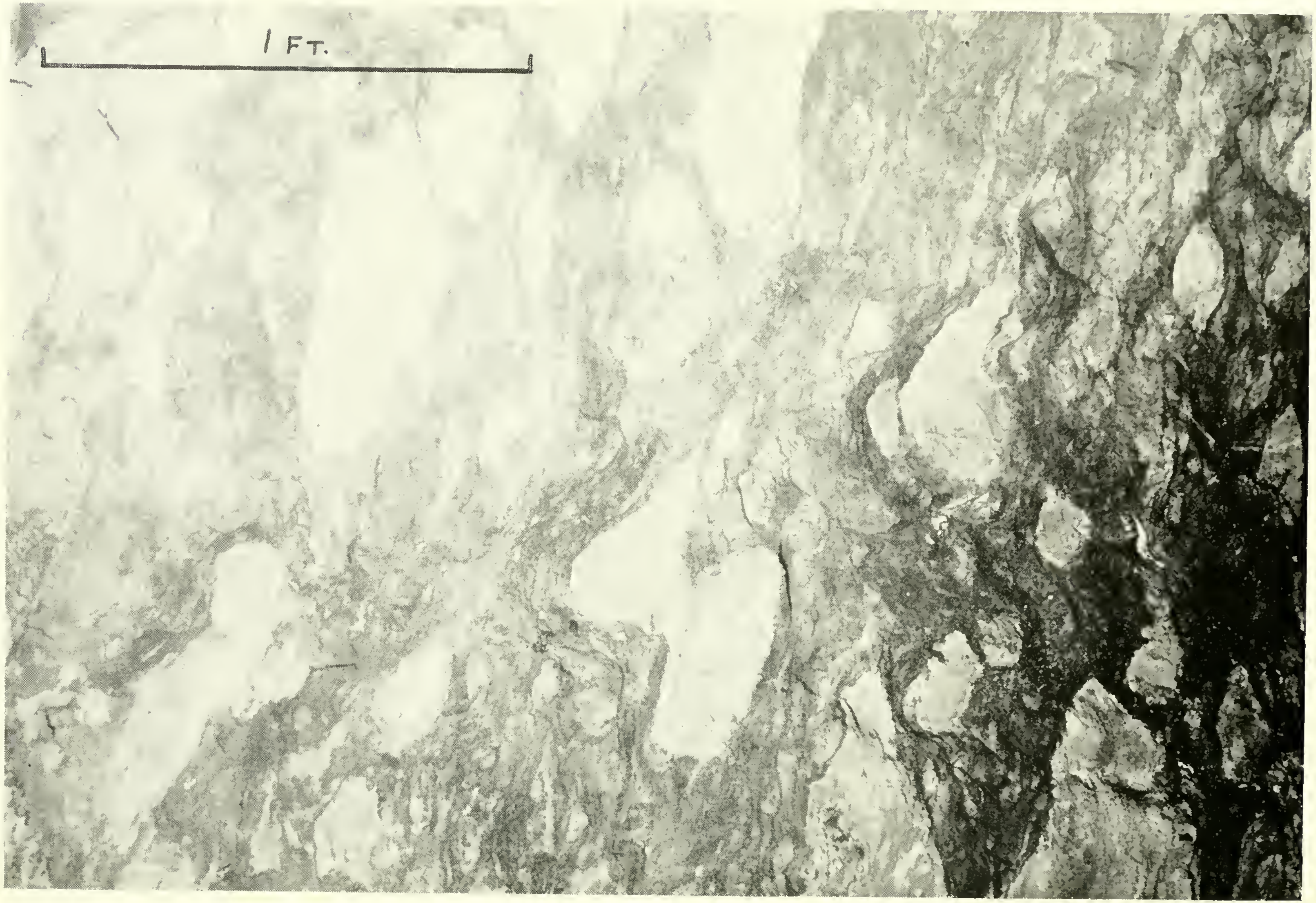
DETAIL OF DEFORMATION IN LOOSE BLOCK OF ALTERED ROCK, HECLA ALTERATION ZONE
Steep schistosity cut by gently dipping shear cleavage, which is approximately parallel to major faults; quartz veins in schistosity curve into shear cleavage.

DRAG FOLD IN BARITIZED SCHIST
Along Satellite fault midway between portal of Penn tunnel and No. 1 shaft collar; looking south.

ALTERED SCHIST RESIDUALS (LIGHT) IN ORE (DARK)
South breast of 500 stope, No. 2 shaft, ore body Ia.

MASSIVE GREENSTONE

View south toward footwall of ore body 5, No. 2 shaft, 1100 level; white quartz along contact; two baritized schist residuals to left of scale.



ALTERED QUARTZ PORPHYRY RESIDUALS SHOWING COBBLY STRUCTURE
In ore, 1100 level, No. 2 shaft, ore body 5.

In 1943 the Eagle Shawmut mine leased the property above the 1,400 level and in July began unwatering it. By December 1943, the company was stoping ore from the 500 level, No. 2 shaft area, and since then regular ore shipments have been made. This operation has been restricted to rehabilitation of some of the workings down to the 1,100 level, No. 2 shaft area, and to the 1,000 level, No. 3 shaft area, and to extracting blocks of ore left by earlier operators. In February 1945 stoping was limited to the 700, 1,000 and 1,100 levels, No. 2 shaft area.

Ore from the Penn mine was hauled by truck about 70 miles to the flotation mill of Eagle Shawmut mine near Chinese Camp, California. The two mill products, a copper-lead concentrate and a zinc concentrate, were shipped by rail from Chinese Camp to the International Smelting & Refining Company's smelter at Tooele, Utah.

The Constellation group of claims is said by local people to have been located by C. H. Borger about 1890. By 1908 the existing shafts had been sunk;[8] since that time the mine has not been operated. In 1916, the State Mineralogist of California [9] reported that "a shaft has been sunk on the Constellation to a depth of 400 feet, and to the south of this shaft one sunk to a depth of 50 feet, cutting a vein 5 feet wide, assaying 3 percent copper with gold and silver values."

In 1943 the United States Bureau of Mines put down a 667-foot drill hole on this property (pl. 15). None of the material from this hole was considered worth assaying; commercial ore was not indicated.[10] Early in 1947 the operators of the Penn mine unwatered the Borger mine for examination purposes.

[8] Aubury, L. E., op. cit., p. 242.
[9] Hamilton, Fletcher, Fourteenth report of the State Mineralogist, for the biennial period 1913-1914: California Min. Bur. Rept. 14, p. 57, 1916.
[10] West belt copper-zinc mines, Amador and Calaveras Counties, California: U. S. Bur. Mines War Minerals Rept. 103, pp. 10-11, 1943.

Table 1. Production of the Penn mine.

Period	Source of data	Ore (tons)	Copper (pounds)	Zinc (pounds)	Lead (pounds)	Gold (ounces)	Silver (ounces)
1861-65	A	3,050	915,000	[1]	[1]	[1]	[1]
1866-67	A	[1]	[1]	[1]	[1]	[1]	[1]
1868-82	A	[2]	[2]	[2]	[2]	[2]	[2]
1883	B	1,000	300,000	[1]	[1]	[1]	[1]
1884-98	A-B	[1]	[1]	[1]	[1]	[1]	[1]
1899-1902	C	[3]81,000	[3]7,500,000	[1]	[1]	6,357.05	173,751
1903-19	C	692,321	67,124,593	[1]	[1]	49,550.92	1,608,087
1920-1942	C	3,083	820,096	[1]	4,906	278.68	9,563
1943-46*	D	83,555	[4]3,321,300	[4]12 293,700	[4]601,000	5,827.00	199,005
Totals	----------	864,009	79,980,989	12,293,700	605,906	62,013.65	1,990,406

Average grade ore. 1903-19: copper, 4.85 percent; gold, 0.07 oz/ton; silver, 2.32 oz/ton.
Average grade ore, 1943-46: copper, 2.05 percent; lead, 5.58 percent; zinc, 7.89 percent; gold, 0.07 oz/ton; silver, 2.37 oz/ton.
* Ore shipments from mine began December 14, 1943, but metal production from smelter was not recorded until February 1944.
[1] No data.
[2] Mine believed to be inactive.
[3] Estimated from gold and silver production.
[4] Pounds of recovered metal.
Source of data:
A—Mineral resources west of the Rocky Mountains, 1866-1876, Mineral Resources of the United States, 1886-1898. Copper production estimated by assuming minimum grade of 15 percent.
B—Copper resources of California, Bulls. 23 (1902), 50 (1908), Calif. State Mining Bureau. Copper production estimated by assuming minimum grade of 15 percent.
C—San Francisco Office, Metal Economics Branch, U. S. Bureau of Mines.
D—Minerals Yearbook, U. S. Bureau of Mines, 1944-46.

GENERAL GEOLOGY

The Penn mine is within a mile of the western edge of the Sierra Nevada foothills, where Paleozoic and Jurassic metamorphic rocks of the Sierra Nevada are overlapped by early Tertiary sediments. The metamorphic rocks consist of a thick sequence of metavolcanic and metasedimentary rocks and are invaded by various intrusive rocks. The area in the vicinity of the mine is underlain by the Mariposa slate and dominantly volcanic rocks tentatively assigned to the Amador group of Taliaferro;[11] both are of Jurassic age.

Bedding and primary layering dip steeply northeast and strike northwest. In general, schistosity and cleavage are parallel to bedding. The geologic map of the Jackson quadrangle[12] suggests that the area studied most likely lies on the west limb of an overturned southward plunging anticline. However, this anticline is probably complicated by faults, by intrusions, and possibly by subsidiary folds.

Zones of sericitization, silicification, and pyritization are developed as belts of considerable width, and as lenses, in metavolcanic and intrusive rocks (pl. 17). These zones follow the regional trend of the rocks, but in detail their contacts are quite irregular, and in many places cross-cutting. It is within these sericitized, silicified, and pyritized rocks, or at their contacts, that the known copper and zinc sulphide lenses are found, and it seems highly probable that in the Penn mine area such lenses are restricted to these zones.

On many of the higher hills in the Penn mine area Tertiary auriferous gravel rests on an unconformity that dips gently westward; below the unconformity the pre-Tertiary rocks are thoroughly decomposed by weathering to a depth of 20 to 25 feet.

In addition to Recent river alluvium, there is another gravel, generally auriferous, interbedded with volcanic ash, which lies on benches developed in relatively unweathered rock. This gravel usually is less than 100 feet above the present river level, and was considered by Turner[13] to be of early Pleistocene age.

STRATIGRAPHY

Mesozoic Sedimentary and Volcanic Rocks

In the Penn mine area the stratigraphic section consists of at least 500 feet of slate, which crops out along the western side, and approximately 2,700 feet of metavolcanic rocks, which underlie the remainder of the area. The lithologic character of the slate is such that it is considered to be Mariposa, which is in accordance with the earlier correlation by Turner.[14] The volcanic sequence, which Turner included in his "amphibolite schist" unit, is tentatively correlated by the writers with the lithologically similar Amador group[15] of Upper and possibly Middle

[11] Taliaferro, N. L., Stratigraphy of the bedrock complex of the Sierra Nevada of California: (abstract) Geol. Soc. America Bull., vol. 43, pp. 233-234, 1932.

——— Bedrock complex of the Sierra Nevada, west of the southern end of the Mother Lode: (abstract) Geol. Soc. America Bull., vol. 44, pp. 149-150, 1933.

——— Geologic history and correlation of the Jurassic of southwestern Oregon and California: Geol. Soc. America Bull., vol. 53, pp. 89-90, 1942.

[12] Turner, H. W., U. S. Geol. Survey Geol. Atlas, Jackson folio (no. 11), 1894.

[13] Turner, H. W., op. cit.

[14] Turner, H. W., op. cit.

[15] Taliaferro, N. L., Geologic history and correlation of the Jurassic of southwestern Oregon and California: Geol. Soc. America Bull., vol. 53, pp. 89-90, 1942.

Jurassic age. The distribution of formations within the area is shown on plates 15 and 16. The contact between the Amador (?) group and Mariposa slate is conformable, and coarse-grained pyroclastics grade upward stratigraphically through 10 to 15 feet of fine-grained, well cleaved, greenish-brown tuff into typical slate. Graded bedding, observed at two places, indicates that the top is to the west; the rocks, therefore, are probably overturned.

Although the portion of the Amador (?) group exposed in the area has a fairly constant stratigraphic thickness, within the group several units show marked changes in thickness, and in some places pinch out. These variations are shown in columnar section (fig. 1). The most striking change is the gradual increase in width of felsic rocks outcropping along the strike from north to south.

Mariposa Slate

The Mariposa slate (pl. 15) consists predominantly of dark blue-gray slate, in some places laminated or thin-bedded, and weathers to pale olive-brown. Within the formation are several fine-grained arenaceous zones. A 25-foot zone of buff arkosic sandstone, showing graded bedding, is exposed on the right bank of the Mokelumne River near the west edge of the area. The slate, but not the sandy beds, generally has a well developed cleavage, locally folded or crenulated.

No attempt has been made to determine the thickness of the Mariposa slate, but at least 500 feet is present and the total thickness may be several times greater.

Amador (?) Group

Meta-andesite and Metadacite Pyroclastics. The uppermost unit of the volcanic rocks tentatively assigned to the Amador group is a sequence of metamorphosed coarse- and fine-grained andesitic and dacitic pyroclastics, (pl. 15). Much of this rock consists of coarse agglomerate with angular and subangular fragments, as much as 18 inches in diameter, in a green chloritic matrix. Coarse- and fine-grained tuffs are less common. Abundant chlorite gives this rock a light- to dark-green color. Epidote is very common, and quartz fragments and quartz grains within rock fragments are present.

The individual beds range in thickness from less than an inch in the finer-grained tuffs to four feet in the coarse agglomerate.

Within this unit near the Mokelumne River is a 20-foot zone of more mafic rock that may represent a basaltic flow. Several thin zones of light-colored tuffs that contain small subhedral quartz crystals are also differentiated on the map.

Metarhyolite Tuff. Underlying the meta-andesite and metadacite pyroclastics is a thin but persistent zone of metarhyolite tuff (pl. 15). This rock is pale green to white and commonly weathers buff. It is generally schistose, and consists of a matrix of altered feldspar, quartz, sericite, and chlorite, with larger fragments of quartz and altered feldspar scattered through it. The thickness is 50 to 65 feet, but about 400 feet northwest of shaft No. 5 it lenses out into the meta-andesite and metadacite pyroclastics.

Metafelsite Pyroclastics. Below the metarhyolite tuff is a sequence of metafelsite pyroclastics (pl. 15) in which are several extensive flows of metabasalt, thin beds of coarse agglomerate with prominent white

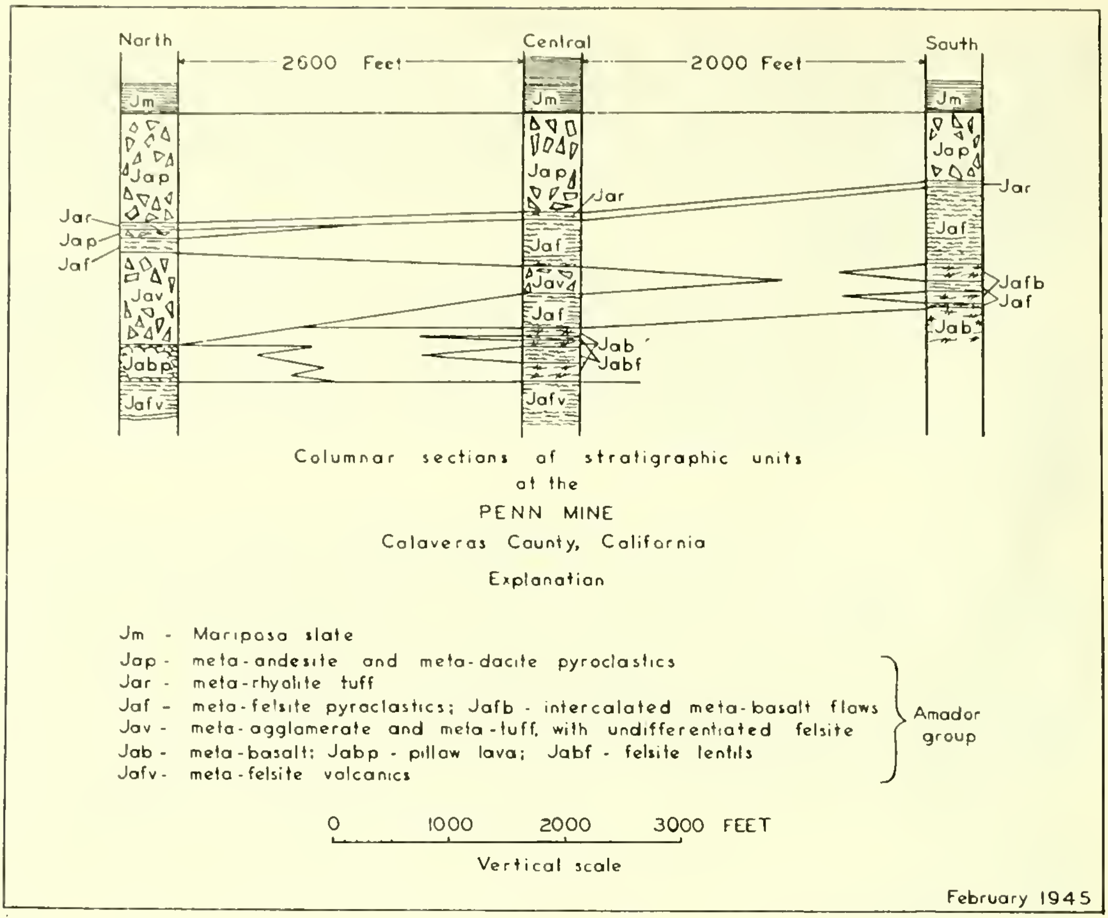


FIG. 1. Columnar sections of stratigraphic units at the Penn mine, Calaveras County, California.

fragments, and small lentils of metarhyolite tuff similar to the overlying unit. In the southern part of the area the thickness is approximately 1,050 feet; northward it interfingers with the underlying meta-agglomerate and metatuff, so that near the northern end of the area it is 125 feet thick or less.

The bulk of the unit is made up of light-green or pale greenish-gray rocks carrying abundant grains of quartz and, locally, feldspar. The finer-grained tuff contains abundant sericite and chlorite, whereas the coarser pyroclastics are characterized by fragments of felsite and quartz porphyry. As in most of the volcanic rocks, weathering accentuates whatever schistosity is present.

The flows are massive or moderately schistose, medium to dark green, and weather dark reddish-brown. They consist mainly of chlorite, epidote, and altered feldspar. Amygdules are present as calcite or ankerite, as clear or white quartz, or as clusters of darker-green chlorite metacrysts. Pillow structure is well developed at several places; the pillows are generally 1 to 3 feet in diameter, and commonly have characteristic red chert in the interstices.

Meta-agglomerate and Metatuff. Underlying the metafelsite pyroclastics at the north and interfingering with them toward the south is a sequence of meta-agglomerate and metatuff (pl. 15), coarse- and fine-grained pyroclastics predominantly of intermediate composition. This unit also includes felsitic tuff and agglomerate, as well as zones of dark-green chloritic lava in places containing quartz and calcite amygdules. In the northern part of the area the estimated thickness is 800 feet, but the unit thins southward and lenses out in the southern part of the area.

The greater part of the pyroclastics of this unit is moderately schistose, medium to pale green, and weathers brown. These schists are composed of chlorite, epidote, and altered feldspar. Fragments in the agglomerate range in diameter from 4 to 6 inches, and scattered bombs are as much as 2 feet in diameter.

The felsitic pyroclastics within this unit are pale gray and weather buff. Minerals present are feldspar, quartz, sericite, and probably chlorite. Tuff predominates, but zones of 1- to 4-inch fragments are not uncommon.

The thicker lava zones within this unit have been differentiated on the areal map. In some places crudely developed pillow structure is present in these flows.

Metabasalt. Underlying the predominantly intermediate meta-agglomerate and metatuff is metabasalt (pl. 15). Toward the north this unit has a thickness of 325 feet or more, and consists of well-developed pillow lavas. To the south pillow structure is absent, and a large composite lentil of metafelsitic tuff occurs within the mafic rocks.

The metabasalt is medium- to dark-green chlorite-epidote schist and greenstone that weathers dark reddish brown. Also present are altered feldspar and sericite. Amygdules of white calcite and clear or white quartz are common. Numerous intercalated zones of coarse (4- to 10-inch) fragments are present; this rock is generally mafic, but locally includes fragments of pale-gray quartz porphyry and felsite. Pillow lava has the characteristic red chert masses between pillows, and individual pillows generally are 1 to 3 feet in diameter, though larger ones exist. This unit is particularly well exposed in the canyon of the Mokelumne River.

Metafelsite Volcanics. Underlying the metabasalt is a thick sequence of metafelsite tuff, agglomerate, and lava (pl. 15), of which only the upper portion lies within the mapped area. Included in the unit are several lenticular areas of mafic rock, probably flows, which are differentiated on the areal map.

These volcanics are typically pale greenish-gray or pale bluish-gray, and weather to pale brown, buff, or white. Quartz, feldspar, sericite, and probably chlorite are the chief minerals. Bedding or layering is evident, particularly in the coarser rock which generally consists of fragments 1 to 6 inches in diameter. Most of these volcanics are aphanitic, or have small laths of white plagioclase in an aphanitic matrix, and some show a well-developed flow banding.

Tertiary and Quaternary Sediments

Because the Tertiary and Quaternary gravels, ash beds, and alluvium have little effect on the bedrock geology other than to conceal it, they are not described here.

INTRUSIVE ROCKS

Quartz Porphyry

The most widespread intrusive rock within the mapped area is quartz porphyry (pl. 15). It forms sills and lens-shaped bodies of considerable size, whose contacts in detail cut across contiguous volcanic rocks. It has abundant phenocrysts of clear vitreous quartz that in some places are euhedral and show the bipyramidal form of beta-quartz. Less common are phenocrysts of feldspar. The groundmass is gray-green to pale greenish-white, and the rock weathers to brown or buff. Weathering brings out a schistosity which on many freshly exposed outcrops is not evident. The margins of some of the bodies, as well as narrow zones within them, are brecciated; the largest of these breccia zones is shown on the areal maps (pls. 15 and 16).

The feldspars consist of about equal amounts of orthoclase and sodic andesine. Both feldspar and quartz occur in the groundmass as phenocrysts. Usually the ferro-magnesian minerals have been altered to chlorite, though some green biotite is seen under the microscope. Magnetite is a common accessory mineral. Sericite, epidote, chlorite, and leucoxene are common alteration products. The rock is quartz latite porphyry.

Where this rock has undergone intense hydrothermal alteration its appearance is greatly changed; it is strongly schistose, and the groundmass consists largely of sericite or white cryptocrystalline quartz or both.

Felsite

Scattered throughout the area are small sills and lenticular bodies of pale-gray felsite (pl. 15) that weathers buff or white. In places minute phenocrysts of quartz and feldspar can be discerned, and some felsite bodies have cores of quartz porphyry, suggesting a common origin. Although some of these felsite bodies may be flows, or possibly very fine-grained tuffs, probably most of them are intrusions.

Greenstone

Two bodies of greenstone (pl. 15), probably of intrusive origin, are present. The larger lies in the southern portion of the area, and extends beyond the limits of mapping. It is a fairly massive, medium-green rock that weathers pale grayish-green. It contains abundant subhedral or rounded small white masses of altered feldspar that may represent phenocrysts, and also numerous dark-green crystals, probably uralite. The groundmass consists of altered feldspar, chlorite, sericite, and some secondary quartz. In the south fork of Oregon Gulch, beyond the southern boundary of the mapped area, the contact of this greenstone locally cuts across adjacent felsite agglomerate, which suggests that the greenstone is intrusive.

The other body of greenstone lies about 500 feet southwest of shaft No. 3. It is lithologically similar to the southern mass, except that light-colored, altered feldspar is considerably less abundant and the rock weathers to a darker green.

Trap

Three small bodies of dark fine-grained to aphanitic rock crop out about 500 feet northwest of shaft No. 2 (pl. 15). The rock is drab-brown or greenish-brown, and weathers reddish-brown to purple. In those varieties where grains can be discerned, the rock seems to be made up largely of altered feldspar and an interstitial green mineral, and has irregular reddish-brown to black spots scattered through it. Cubic pseudomorphs of limonite after pyrite occur sporadically in the rock. It is given the field term trap. The rock has an unsystematic, closely spaced, smooth fracture, so that it breaks on weathering into small, more or less equidimensional chunks.

Relative Age of the Intrusions

With the exception of the trap, which is massive, the intrusive rocks have a schistosity that is generally parallel to the foliation of the surrounding volcanic rocks and slate. Thus these intrusions antedate the regional orogeny, and possibly they are slightly later manifestations of Amador vulcanism. The fine-grained character of the intrusive felsite in particular corroborates this, for it suggests emplacement at shallow depth, before a thick cover had accumulated.

The trap intrusions are later than the quartz porphyry, because they intrude it. The absence of foliation suggests they may have been emplaced after the major regional stresses had been relieved. Although the trap intrusions are considerably altered, they are possibly of Tertiary age. A careful regional study, including known Tertiary igneous rocks that lie outside the mapped area,[16] might solve this problem.

ROCK ALTERATION AND QUARTZ VEINS

Hydrothermal Alteration

Along certain belts and in small lenticular areas the effects of sericitization, silicification, and pyritization have been superimposed on the low-grade metamorphic rocks. The sulphide ore bodies are restricted to these zones of alteration. Near the Penn mine altered rocks are distributed in six main zones, as shown on plate 17. These zones are as much as 225 feet wide and 2,850 feet long; their downward extent appears to be at least as great as their length, and is probably greater. They have been called "veins," "dikes," and "lodes."

The West alteration zone is confined almost exclusively to a sill-like body of quartz porphyry; the other zones are developed mainly in fine-grained felsitic rocks. By and large, the alteration is in felsic rocks, as shown on plate 17. The Hecla zone, which appears to be surrounded largely by intermediate or mafic rocks, actually is developed in a narrow belt of felsic rock, as shown on plate 15. At the few places where alteration has extended into mafic rocks the zones are short and narrow. In the Mariposa slate hydrothermal alteration has not been observed.

The transition from unaltered to altered rock is gradual within felsic rocks, but alteration generally ends abruptly at the contact between felsic and mafic rocks. Also within the alteration zones the transition from sericitized to silicified rock is gradual in many cases.

Sericitized rock includes sericite schist and quartz-sericite schist, and contains as much as 5 percent pyrite. Silicified rock consists dominantly of cryptocrystalline quartz with poorly developed parting, and contains as much as 20 percent pyrite. In some places folia of sericite are crossed by minute veinlets of silica, and appear to be partly replaced by them. In quartz porphyry, sericite folia wrap around vitreous quartz phenocrysts, which persist in all but the most intensely silicified rock. In many places sericitization has been more extensive than silicification. Not uncommonly areas of alteration have cores of silicified rock, with silicification becoming less intense outward, and grading into margins

[16] Turner, H. W., op. cit.

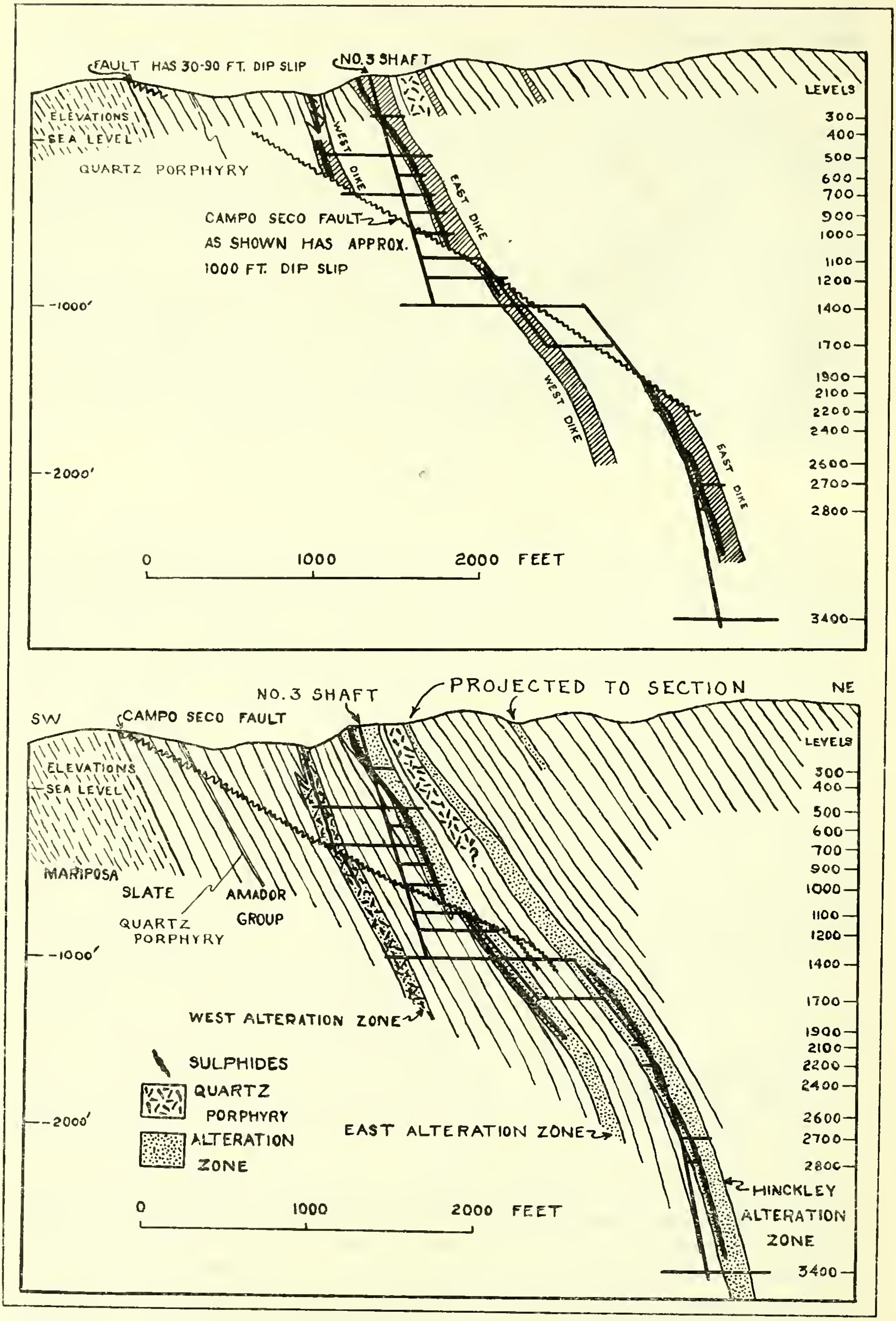


Fig. 2. Interpretations of Campo Seco fault, Penn mine, Calaveras County. Top, Tolman's interpretation corrected to scale, surface geology added; bottom, authors' interpretation.

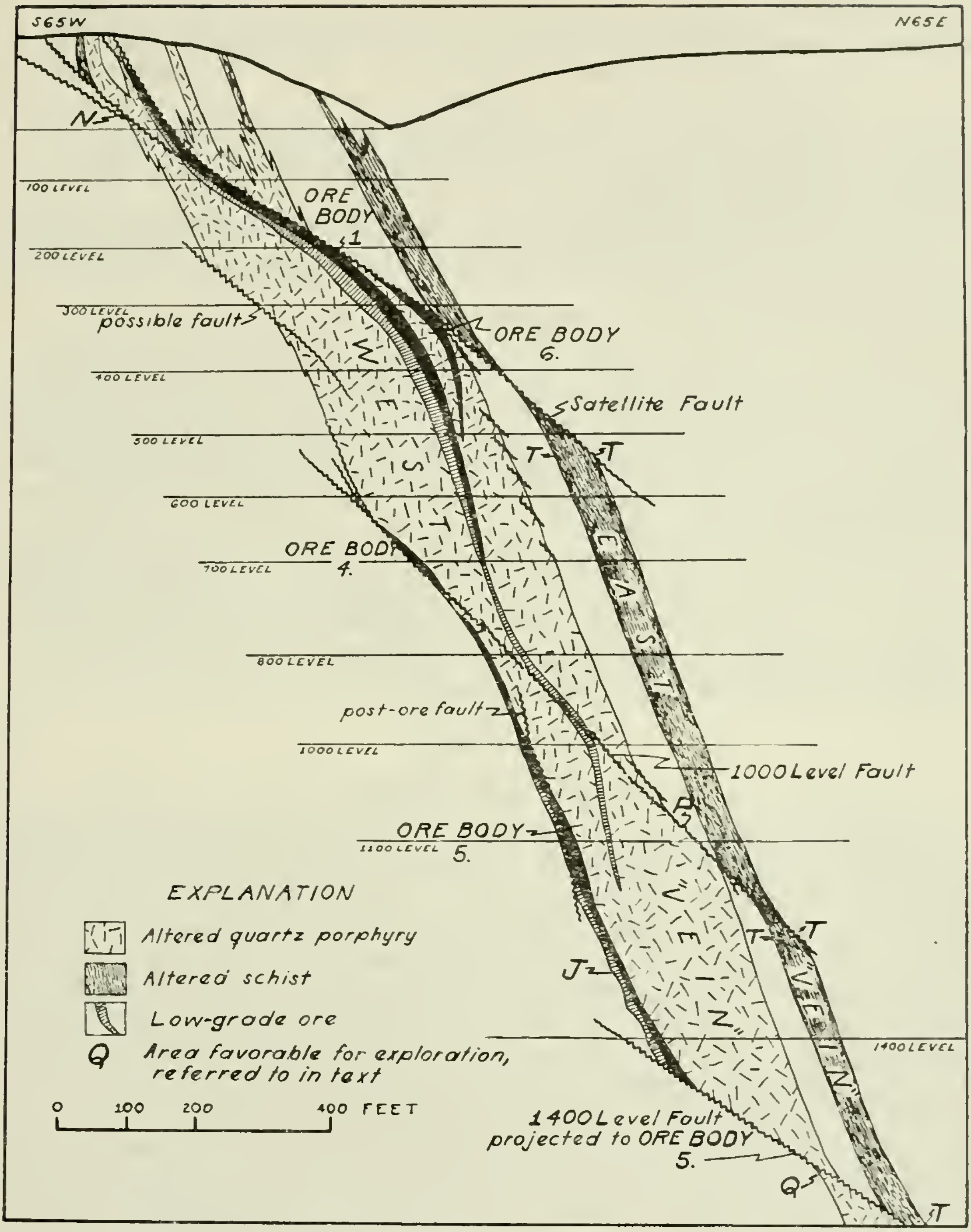


FIG. 3. Composite section through the No. 2 shaft area, Penn mine, Calaveras County, California.

of sericitized rock. This is well shown by the southern part of the East alteration zone, and by parts of the Borger and West alteration zones.

Northward and southward from shaft No. 2, four narrow areas, within or adjacent to the West alteration zone, are underlain by red hematitic jasper having a poorly developed schistosity. Locally this rock is cut by many veinlets of clear quartz, and near shaft No. 2 it appears to be partly replaced by sericite.

Finely disseminated magnetite is locally abundant along the contact between the West alteration zone and felsitic schists, about 450 feet southwest of shaft No. 3.

Quartz Veins

Veins of milky quartz are present throughout the area, and locally occur as swarms. They range from a fraction of an inch to several feet in thickness, the larger ones are shown on plates 15 and 16. Epidote is abundant in these veins, particularly in those that cut epidote-rich rocks. Chlorite and calcite are less common, and in places copper staining or a few grains of pyrite are present.

The relative age of these veins has not been determined with certainty. They apparently were introduced after the regional metamorphism, for in many cases they follow the schistosity. In parts of the West alteration zone they are folded and brecciated, indicating that some deformation occurred after their formation.

STRUCTURE

Schistosity and Cleavage

Schistosity or cleavage is present in nearly all types of rock, but varies considerably in intensity. This schistosity is most pronounced in alteration zones, particularly where the rocks have been sericitized; in the more massive greenstone it is little more than incipient. This is due in part to the large quantity of sericite in altered rock, but it seems not unlikely that the greater fissility of the altered rock predates the entrance of hydrothermal solutions. In general, schistosity strikes parallel to bedding, and dips eastward, parallel to, or 5° to 15° more gently or steeply than the bedding, possibly indicating the presence of minor folds.

Shear cleavage is developed in altered rock in the West and Hecla alteration zones, and in adjacent metafelsite breccia. This cleavage consists of closely spaced shear planes which are nearly parallel to major low-angle reverse faults. Minor reverse movements also occurred on the shear cleavage, displacing schistosity planes a fraction of an inch (pl. 28). The strike of the shear cleavage ranges from about parallel to schistosity to as much as 40° more east or west, and the dip is generally less than 50° east.

Lineation

Linear elements consist of crinkles in schistosity in altered rock, in addition to slickensides and mullions on faults, and of long axes of fragments and pillows in unaltered rock. These linear elements plunge[17] steeply, generally nearly down-dip. Some of the lineation may be due to intersections of schistosity and shear cleavage, but most of it is probably a result of either strike-slip rolling along schistosity, or dip-slip stretching. Fragments or pillows, where distorted, show flattening in the plane

[17] Plunge, as here used, is defined as the vertical angle between a horizontal plane and the line of maximum elongation.

of foliation, and maximum stretching along axes approximately parallel to the dip; this deformation seems to be the consequence of regional compression.

Folds

Minor folds in bedding were observed in a few places; the most pronounced are in the Borger alteration zone northwest of the Borger shaft. Fold axes plunge from 60° S. through vertical to 85° N., and nonfolded schistosity is parallel to axial planes of the folds. The irregularities in the contact between metabasalt pillow lava (pl. 15) and metafelsite volcanics in the northeast part of the area may be due to folding, although equally plausible hypotheses are that they are caused by cross-faulting, or interfingering. Most of the other irregularities in stratigraphic contacts that appear in plates 15, 16, and 17, are probably due to interfingering, although in plan many resemble plunging folds.

Locally the schistosity itself is folded on a small scale, and randomly plunging minor folds in schistosity are developed in shear planes either within alteration zones or along contacts between different kinds of rock. In addition there are many small drag folds in schistosity adjacent to faults (pl. 29).

In general, bedding folds are probably a result of the regional orogeny, for in them schistosity is undeformed. The schistosity folds are associated with faults, shear zones, and other zones of later movement.

Faults

Faults can be grouped into three categories: (1) generally steeply dipping faults that strike northeast and have little effect on ore bodies; (2) relatively low-angle reverse faults that strike N. 30° W. to N. 30° E. and dip 25° to 55° E., with a few complementary west-dipping faults: and (3) high-angle faults along certain schistosity planes or at contacts.

The steep northeast-trending faults dip 60° to 85° eastward, but locally are vertical or dip westward. They range from tight structures to open, breccia-filled fissures as much as 30 inches wide, generally with a small amount of gouge. These faults extend only a few feet along the strike, and displacement, where it can be observed, as in the 700-level stope, No. 2 shaft area, amounts only to a strike-slip movement of 2 to 9 feet. In the 700-level stope, ore occurs at the intersection of these faults with the greenstone footwall of the West alteration zone, and thus the faults here antedated the ore deposits. However, much of the movement along these faults occurred later than low-angle reverse faulting and ore deposition.

The second type, low-angle reverse faults, are by far the most significant. These pre-ore faults are one of the chief structural controls of the ore bodies, although post-ore movement along some of them has displaced ore. Four major faults of this type have been recognized at the Penn mine: the Satellite, 1,000-level, Campo Seco, and 1,400-level faults. The Satellite fault crops out at the surface (pl. 26), where it has been mapped for a distance of 1,200 feet (pls. 15, 16, and 17), and is present in the upper workings, No. 2 shaft area (pls. 20, 21, and 23). The 1,000-level fault was seen in the 1,000 and 700 levels, No. 2 shaft area (pl. 19, fig. 3). The Campo Seco fault has been observed at the surface (pls. 15 and 17) and in shaft No. 3 between the 1,000 and 1,100 levels (pl. 24, fig.

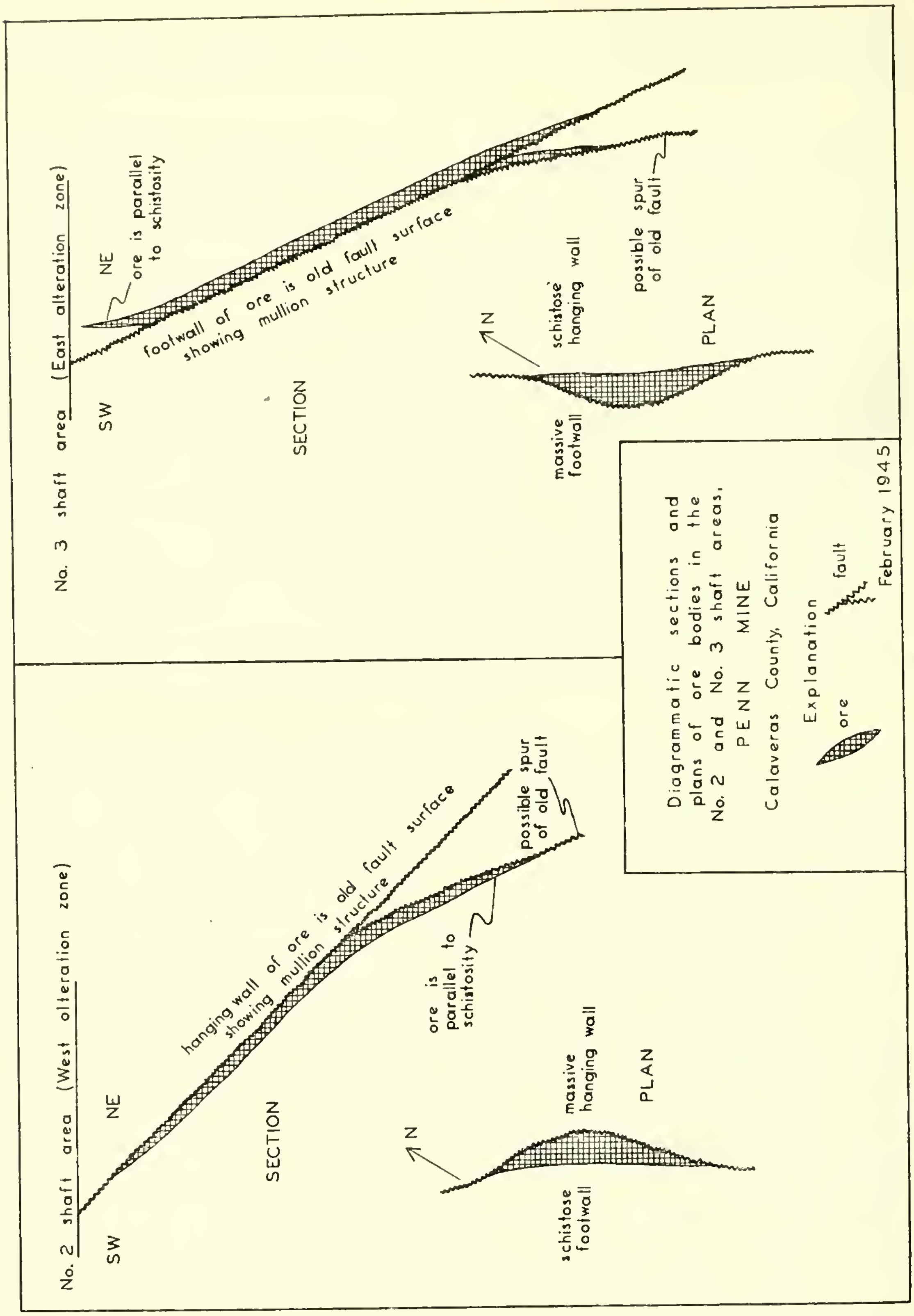

No. 3 shaft area (East alteration zone)
SW
NE
ore is parallel to schistosity
footwall of ore is old fault surface showing mullion structure
SECTION
N
schistose hanging wall
possible spur of old fault
massive footwall
PLAN
No. 2 shaft area (West alteration zone)
SW
NE
hanging wall of ore is old fault surface showing mullion structure
possible spur of old fault
ore is parallel to schistosity
SECTION
N
massive hanging wall
schistose footwall
PLAN
Diagrammatic sections and plans of ore bodies in the No. 2 and No. 3 shaft areas,
PENN MINE
Calaveras County, California
Explanation
ore
fault
February 1945

FIG. 4.

2), where it is marked by 1 to 2 feet of breccia. From company maps it is inferred that the 1,400-level fault lies in the deepest workings, No. 2 shaft area (fig. 3) ; it may be the southward extension of the Campo Seco fault, but, if not, the Campo Seco fault lies below this fault.

The Satellite fault consists of a main branch, which near the surface is the hanging wall of ore body 1, and several footwall spurs. It has an average strike close to north, and dips about 45° E., but locally trends N. 20° W. to N. 20° E. and ranges in dip from 25° to 75°. At the 200 level, No. 2 shaft area, the fault forms the hanging wall of ore body 1a, and in the south stope on the 500 level it forms the hanging wall of ore body 1b. If movement along the Satellite fault is assumed to be rotational, with little or no displacement at the northernmost surface exposure, the dip-slip at the collar of shaft No. 1 is about 170 feet. This figure is obtained by determining the dip-slip (about 300 feet) near the southernmost surface exposure, where the strike-slip is known. The dip-slip at any point is then proportional to the distance from the northernmost exposure.

According to Julihn and Horton[18] the Campo Seco fault strikes N. 12° W. and dips 29° E. A cross-section by Tolman[19] shows it with a dip-slip of about 1.000 feet (fig. 2). The writers question Tolman's interpretation, mainly because no fault of requisite magnitude was observed at the surface. If Tolman's interpretation is correct, his West "dike" below the fault should be the downward continuation of the alteration zone developed in quartz porphyry, and the 1,400 level footwall and hanging-wall crosscuts would not extend into other alteration zones. These critical locations were not accessible to the writers. If the writers' interpretation (fig. 2) is correct, the fault has a dip-slip on the order of 30 to 90 feet, and shaft No. 3 workings partly explore three alteration zones: the West (in quartz porphyry), the East, and the Hinckley; unless the West zone pinches out with depth, all three should be present on the 1,400 level. The importance of determining the amount of displacement along the Campo Seco fault cannot be overemphasized, for if the displacement is small, as the writers believe, considerably more ground below the fault is favorable for exploration.

These low-angle faults commonly are fault zones, and generally consist of many closely spaced en echelon faults (pl. 27). Mullions plunge down-dip, and drag in schistosity indicates reverse movement. Because sulphide stringers follow along these faults and their associated drag folds, low-angle reverse faulting is believed to have occurred before the introduction of sulphides. However, later movement on these faults has actually brecciated ore, as for example the ore in a short raise near the south end of the 500 level, No. 2 shaft area.

The high-angle faults developed along certain schistosity planes or contacts are evidenced by fairly coarse mullion structure, by schistosity drag folds, and by prominent surfaces with strongly developed lineation. These faults antedate those of the other two classes, and are believed to represent a type of failure common in the felsic rocks of the area, which may be a reason for the localization of sericitization and silicification in belts of these rocks.

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[18] Julihn, C. E., and Horton, F. W., op. cit., p. 114.

[19] Tolman, C. F., The Foothill copper belt of California, XVI Internat. Geol. Cong., Copper Resources of the World, vol. 1, pp. 247-250, 1935.

ORE BODIES OF THE PENN MINE

General Features

The ore bodies at the Penn mine are sulphide replacement deposits in alteration zones of sericitized, silicified, and pyritized schist, derived from felsitic volcanic rocks and intrusive quartz porphyry. In general the intensity of silicification and pyritization decreases away from the ore which is typically a fine-grained mixture of pyrite, chalcopyrite and sphalerite. The ore bodies have a lenticular form, with long axes plunging down-dip or steeply northward or southward.

The metasomatic origin of the ore bodies is indicated by the following features: (1) banding in the ore and strong relict schistosity in the pyritic envelope surrounding ore, both parallel to foliation of country rock; (2) retention, in sulphides and gangue, of drag folds in schistosity and minor faults (fig. 29); (3) oriented residuals of schist within ore and the pyritic envelope (pls. 30, 31, and 32); and (4) the gradational contact of at least one wall, and in some cases both walls, of the ore bodies.

Except for the ore body at shaft No. 5, the known ore bodies are shown in plan, section, or projection on plates 17-23; for convenience in reference, they are designated by number. Ore bodies 1a, 1b, 2, 3, 4a, 4b, 5, and 6 are in the West alteration zone, 7a and 7b in the East alteration zone, and 8a and 8b in what is probably the downward extension of the Hinckley alteration zone. The ore body at shaft No. 5, which is inaccessible, is in the Hecla alteration zone.

The ore bodies occur at either the hanging-wall or footwall contact of alteration zones; or within these zones either along high-angle faults parallel to schistosity, or along younger low-angle reverse faults that crosscut and drag schistosity, and offset alteration contacts. The low-angle faults, some of which show post-ore movement, are readily recognized by slickensided surfaces and gouge. The older high-angle faults along certain schistosity planes or at contacts are less obvious, for evidence generally is limited to coarse mullion structure and strong lineation approximately down the dip of foliation. The intersection of a low-angle fault with an older high-angle fault is a locus particularly favorable for ore deposition (figs. 3 and 4). Both types of faults are present on a minute scale measured in inches (pl. 28), as well as on a scale measured in tens or hundreds of feet (fig. 3).

Another factor in the localization of ore, at least in some cases, is the large-scale gentle bowing of faults and schistosity normal to their strike (pl. 10). Within these areas of buckling, which actually are steeply pitching chimneys, the schistosity is more intricately folded and faulted, and in places is steeper than normal or dips west. The geologic level maps (pls. 18 and 19) show in plan that ore bodies 1a, 1b, and 6 are concave westward, and ore body 7a is concave eastward (fig. 4). There is also a suggestion that the upper portion of ore body 5, the probable downward extension of ore body 2, and possibly deep ore bodies 8a and 8b, all of which are inaccessible, are concave westward.

In cross-section the ore bodies show several typical forms which are controlled by one or more of the structural features mentioned above. The simplest type is an elongate body, pod-shaped in cross-section, developed along or near a contact of an alteration zone (ore bodies 4 and 5, pl. 20, fig. 3), or along a zone of strong deformation within an alteration zone (ore bodies 2, 3, and the north part of 1a, pl. 22). A second type differs from the first in that its upper portion flattens and follows a low-angle fault (ore bodies 1b, the south part of 1a, and probably 6, pls. 20, 21, fig. 3). A third type is exemplified by ore body 7a (pl. 24), whose central portion follows an old fault at the footwall of an alteration zone, but whose upper and lower portions leave the footwall and follow steeper schistosity. These last two types, with their structural relationships, are shown diagrammatically in fig. 4.

The ore bodies vary considerably in size. Ore bodies 7a and 7b were mined along a pitch length of about 1,000 feet; the original length was greater, for parts of the ore shoots have been removed by erosion, and, in addition, a faulted extension probably exists below the 1,100 level. Ore bodies 1a and 1b have known pitch lengths of about 825 and 700 feet respectively, and from these, some ore has likewise been removed by erosion. The deep ore body (8a) in No. 3 shaft area has a pitch length of at least 900 feet, and 8b, just to the south, at least 650 feet. Ore body 5 has a minimum down-dip extent of 300 feet, and its pitch length is probably considerably greater. Of the smaller bodies, ore body 3 has a pitch length of 150 feet or more.

Ore bodies 1a and 1b, where they merge in the upper levels, were stoped along a distance of 600 feet or more; at greater depth, the breadths of ore bodies 1a and 1b are respectively 400 and 325 feet. Ore bodies 7a and 7b have breadths, respectively, of 300 and 250 feet, and where they merge with depth were stoped for a distance of 400 feet or more. The two deep ore bodies (8a and 8b) have breadths of 175 and 250 feet respectively. Of the smaller bodies, Nos. 2 and 3 have breadths close to 100 feet.

In width the ore ranges from about 4 to 30 feet. Ore was 20 feet wide at places in ore bodies 1a, 1b, and 5. Most ore bodies have high-grade ore ranging in width from 5 to 12 feet.

Characteristics of the Ore

In the Penn mine sulphides are present as (1) massive ore, which is either uniform or banded, (2) stringers or narrow irregular masses, (3) disseminated grains, or veinlets which cut the other types. The massive and the stringer ores are fine-grained, intimate mixtures of pyrite, sphalerite, chalcopyrite, and a small amount of bornite; gangue minerals, which are generally sparse, are calcite, barite, and quartz. The disseminated ore consists of fine grains of pyrite, sphalerite, and chalcopyrite scattered through the silicified, sericitized wallrocks. The ore in veins, which range in thickness from a fraction of an inch to a foot and a half, is later than the other types. These veins have no systematic attitude. They are composed of pyrite, chalcopyrite, bornite, and some tetrahedrite, with white calcite and quartz gangue that in places contains a little chlorite. On the 1,100 level, in the southern portion of ore body 5 and close to its footwall, a small amount of visible native gold occurred in a pocket in one of these veins.

The pyritic envelopes of the ore bodies are made up of abundant pyrite disseminated in altered wallrock. The pyrite is generally fine grained, and may be present as cubes, pyritohedrons, or anhedral grains. Within the envelopes certain streaks or bands of schist may show local concentrations of pyrite, but in a general way, pyrite becomes less abundant outward from the ore bodies. A striking feature of some ore is the presence of residual masses of silicified, sericitized schist and quartz porphyry in the sulphides. Some of them are schistose and elongate, and oriented parallel to the schistosity of the country rock (pls. 30 and 31); others are more rounded and massive, locally giving the ore a "cobbly structure" (pl. 32). In a general way, these residual masses are more numerous and more closely spaced in the tapering ends of ore bodies and near gradational contacts. Possibly some of the residual masses represent fragments in fault breccias developed before ore deposition. If this is true, the sulphides probably selectively replaced finely comminuted rock, leaving the more impervious larger fragments as residual masses.

Julihn and Horton [20] state that, in general, ore from the Penn mine contains 0.03 to 0.10 ounce of gold and 2 to 4.5 ounces of silver per ton, 3 to 6 percent copper, and 5 to 15 percent zinc. The ore mined during the recent operation is not typical, because it came only from ore bodies of the West alteration zone, and in addition only the higher-grade ore was mined. There is a suggestion that ore in this zone contains more zinc and less copper than ore of other zones. Past records indicate gold and silver also are more abundant in ore from the West alteration zone.

Supergene Enrichment and Gossans

Because the upper workings were inaccessible, little was learned in the recent study regarding supergene enrichment. On the 200 level chalcocite was present as sooty coatings on primary sulphides. Aubury [21] states that copper glance was found in the upper portions of the "veins," and that scattered copper glance and covellite occurred in the deeper parts of the mine, then 750 feet deep.

Throughout most of the Foothill copper belt the zone of enrichment lies within 20 to 60 feet of the surface. However, at the Penn mine oxidation and enrichment of the ore may have penetrated deeper than normal, for the present erosion surface in many places is close to the pre-Tertiary unconformity, which was developed during a period of intense and prolonged weathering.

The outcrops of ore bodies are marked by gossans, and between No. 1 and No. 2 shafts by copper carbonates as well as gossan. The gossans derived from ore are commonly brown or yellow-brown, and contain malachite, azurite, jarosite, limonite, and kaolin, in addition to residual quartz, sericite, and barite. The gossans derived from pyritic material are generally red-brown and usually more siliceous. The larger gossan areas are shown on plates 15 and 16.

Mineralogy and Paragenesis

Pyrite is present as cubes and pyritohedrons or as anhedral grains disseminated in wallrock and occurring within sulphide bodies. It is generally fine-grained, though some cubes are a quarter inch on a side. The banded ore not uncommonly is delineated by narrow, regular, pyrite-rich bands, and some altered wallrocks have apparently been replaced selectively along certain layers.

Sphalerite is a dark-brown to steel-black variety that probably contains combined iron. It is typically fine-grained, for grains larger than one-tenth inch in diameter are rare. It is found intimately mixed as.

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[20] Julihn, C. E., and Horton, F. W., op. cit., pp. 112-113.
[21] Aubury, L. E., op. cit., p. 241.

grains and streaks with pyrite, chalcopyrite, bornite, and gangue minerals.

Chalcopyrite occurs as anhedral grains and aggregates of grains that may form streaks in the ore matrix. In the calcite-quartz veins it occurs in coarser masses than in the massive ore. Bornite is locally intergrown with chalcopyrite, but is relatively rare except in the calcite-quartz veins. Tetrahedrite is also present in these veins, but was not observed in massive ore. Galena was seen only in a few specimens, where it was sparsely present; it has been identified microscopically by Tolman,[22] who considered it the latest of the hypogene sulphides.

Barite, commonly fine grained and pale gray, buff, or white, is locally abundant along the margins of ore bodies of the West alteration zone. It is intergrown with sulphides, especially sphalerite, and replaces residuals of country rock within ore bodies (pl. 31). It may also replace wallrock, locally preserving schistosity as a relict structure (pl. 29). A common occurrence of barite is in axial regions of schistosity drag folds in altered quartz porphyry.

Fine-grained white calcite is generally sparsely present as gangue in massive ore, and coarsely crystalline calcite and milky quartz are abundant in sulphide-bearing veins that cut massive ore. Chlorite was observed in a few places intergrown with the milky quartz of these sulphide-bearing veins. Sericite folia are parallel to schistosity of the enclosing rock at ore boundaries, and in one case a thin layer of a sericitic mineral, probably damourite, was present as folia perpendicular to the margin of a bornite-calcite-quartz vein. Pale-gray to white cryptocrystalline quartz, characteristically replaces the wallrock, and in places is present in massive ore.

Selenite occurs as clusters of crystals and as masses coating mine workings and was also observed as cavity fillings in ore body 5. It is probably supergene. Small botryoidal and dendritic masses of native copper were observed at many places in mine workings, coating walls and replacing old pieces of steel. It is reported by Aubury[23] in the upper portion of the "vein," where it was probably a mineral of the oxidized zone.

The paragenesis of minerals associated with the ore deposits is given in table 2. As this table is based on megascopic evidence, it is tentative. Galena and native gold, though present in the mine, are not shown in the table because they were seen in too few specimens for a valid opinion to be formed as to their position in the paragenetic sequence; it seems probable, however, that they are among the later hypogene minerals.

Summary of Ore Controls

The ore controls recognized at the Penn mine are summarized as follows:

(1) Ore is apparently restricted to belts of sericitized and silicified schist derived from quartz porphyry and felsitic rocks. Whether ore deposition favored these belts because of chemical selectivity, or because these rocks were deformed in a manner favorable for circulation of replacing solutions is not known, but the second hypothesis is preferred.

[22] Tolman, C. F., op. cit., p. 249 ff.
[23] Aubury, L. E., op. cit., p. 241.

Table 2. Paragenesis of epigenetic minerals at the Penn mine (based on megascopic evidence)

HYPOGENE			SUPERGENE
Rock alteration stage	Sulphide replacement stage	Vein-forming stage	
Sericite		Sericite or Damourite	
Cryptocrystalline quartz			
	Pyrite		
	Sphalerite		
	Barite		
	Chalcopyrite		
	Bornite		
		Calcite	
		Milky quartz	
		Tetrahedrite	
		Chlorite	
			Chalcocite
			Malachite
			Azurite
			Gypsum
			"Kaolin"
			"Limonite"
			Jarosite
			Native copper

(2) Within the alteration zones and at their margins are areas of gentle bowing or buckling in a direction normal to schistosity. These areas, or, more accurately, chimneys of greater disturbance, represent favorable loci for ore deposition.

(3) Within the alteration zones and at their margins, the intersections of high-angle schistosity faults with younger, low-angle reverse faults produce loci favorable for ore deposition.

(4) Small, tight, schistosity folds, unsystematically oriented and generally with amplitudes measured in inches, are specific ore controls, for in places along their axes pencils of sulphides or barite are developed.

Of these four controls, the first is useful in delineating belts of country in which ore bodies may occur. The second and third, used in combination, can be applied to locating specific areas where ore might be found. The fourth probably has little economic significance, for the size of the controlling structures precludes commercial ore bodies.

GEOLOGIC HISTORY

The geologic history of the area near the Penn mine is summarized as follows:

(1) During Upper and possibly Middle Jurassic time a thick sequence of volcanic and sedimentary rocks was deposited in a marine basin which included the Penn mine area. Evidence for the marine origin of these strata was not found in the Penn mine area; it is inferred from the presence of marine fossils found elsewhere in the Mariposa slate and formations of the Amador group.

(2) Quartz porphyry, felsite, and mafic rocks were intruded into these rocks.

(3) In late Upper Jurassic time these rocks were folded, faulted, and underwent low-grade metamorphism (Nevadan revolution).

(4) Certain belts of these rocks were affected by hydrothermal alteration, followed by faulting and associated folding, formation of sulphide deposits, then more faulting.

(5) During Cretaceous and early Tertiary time the region was subjected to erosion and weathering, followed by deposition of Tertiary sediments, and finally by canyon-cutting and deposition during the Quaternary period.

AREAS FAVORABLE FOR EXPLORATION

Areas considered favorable for exploration are listed below.

(1) *Extensions of known ore bodies*

In West alteration zone, No. 2 shaft area:

A. South extension of ore body 1 above 200 level.
B. Downward extension of ore body 3.
C. Downward extension of ore body 6.
D. Downward extension of ore body 1b.
E. Upward extension of ore body 5.
F. Downward extension of ore body 4a.
G. Downward extension of ore body 4b.
H. South extension of ore body 5.
J. Downward extension of ore body 5 (fig. 3).

In Hecla alteration zone:

K. Downward extension of ore body at shaft No. 5.

In Hinckley alteration zone:

L. Upward extension of ore body 8b.
M. Downward extension of ore body 8a.

(2) Areas, other than extensions of known ore bodies, based on geologic inferences.

In West alteration zone, No. 2 shaft area:

N. Area beneath footwall spur of Satellite fault south of shaft No. 2 (pl. 21, fig. 3).
P. Area below the intersection of the 1,000 level fault with hanging wall contact of the West alteration zone (fig. 3).
Q. Areas below the intersections of the 1,400 level fault with footwall and hanging-wall contacts of the West alteration zone (fig. 3).

In West alteration zone, No. 3 shaft area:

R. Area below gossans and disturbed zone extending from the Busey adit northward for 500 feet.
S. Area below intersection of the Campo Seco fault with the West alteration zone.

In East alteration zone, No. 2 shaft area:

T. Areas at the intersections of the Satellite, 1,000 level, and 1,400 level faults with footwall and hanging-wall contacts of the East alteration zone (pl. 23, fig. 3).

In East alteration zone, No. 3 shaft area:

U. Hanging-wall contact of the East alteration zone between the 500 and 1,100 levels.

V. Area below the 1,700 level.

In Hinckley alteration zone:

W. Area above the 1,400 level.

OUTLOOK

The plan of the workings at the Penn mine suggests that throughout most of its history only a relatively small amount of systematic exploration for additional ore bodies was carried on. It seems very likely, therefore, that a well-planned and comprehensive exploration program at this mine and its immediate vicinity might uncover additional ore reserves. Such reserves, together with those known to be present at the mine, make the Penn mine area one of the most promising in the Foothill belt.

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THE GRAYHOUSE AREA, AMADOR COUNTY, CALIFORNIA *

By George R. Heyl **

OUTLINE OF REPORT

ILLUSTRATIONS

INTRODUCTION

The Grayhouse area is located in southwestern Amador County, the southern boundary of the area being the Mokelumne River, which is the county line. It lies in secs. 28 and 33, T. 5 N., R. 10 E., Mount Diablo base and meridian. A surfaced county road crosses the central portion of the area, and connects Buena Vista on the north with Lancha Plana to the southwest.

The Grayhouse area lies to the north of the Penn mine area; it includes the northward extension of the belt containing the Penn mine.

The area is at the western edge of the Sierra Nevada foothills, where the metamorphic rocks of this range are overlapped by Tertiary sediments of the San Joaquin Valley. Maximum relief within the area is approximately 370 feet. The Mokelumne River, a trunk stream of the western slope of the Sierra Nevada, forms a canyon along the southern border of the area. The chief subsidiary streams are Barnett Gulch and East China Gulch, both tributaries of the Mokelumne River.

The area mapped covers portions of the properties owned by L. W. Thayer of San Francisco, by H. G. Kreth of Amador County, and by Charles K. Patmon of Lockeford, California.

The Grayhouse mine lies in the central portion of the area. The underground workings were inaccessible to the writer because the mine is filled with water. The mine is reported by L. W. Thayer [1] to have been inactive since 1907, and to consist of a 250-foot shaft, with levels at 40, 200, and 240 feet. He also states that the 40-foot level consists of a drift extending 50 feet northward from the shaft; that the 200-foot level consists of a crosscut extending 210 feet eastward and 30 feet westward from the shaft; and that the 240-foot level consists of a crosscut and drift that extend about 700 feet northwestward.

* Published by permission of the Director, Geological Survey, U. S. Department of the Interior. Manuscript submitted for publication March 1, 1948.

** Geologist, Geological Survey, U. S. Department of the Interior.

[1] Thayer, L. W., Personal communication.

In addition to the Grayhouse mine, there are prospect shafts, adits, pits, and trenches in other parts of the area; their locations are shown on plate 33. Most of the pits in Tertiary gravels are old gold diggings.

In 1943 the U. S. Bureau of Mines put down an 833-foot diamond-drill hole in the area; its location is indicated on the map (pl. 33). The hole was pointed S. 74° W., at an angle of —45°. No material worth assaying was found.

The Grayhouse area was studied at intervals during 1943-45 as part of the U. S. Geological Survey's wartime investigations of the Foothill copper-zinc belt. The topography of the area was mapped by M. W. Cox, D. G. Wyant, and M. H. Staatz. Triangulation points were established by M. H. Staatz and M. W. Cox, by extending the Penn mine system northward.

The writer is responsible for the geologic mapping of that portion of the area northward from the latitude of Grayhouse; M. H. Staatz is responsible for that south of Grayhouse; and along the north bank of the Mokelumne River, both M. H. Staatz and the writer have contributed to the mapping.

The writer wishes to acknowledge the many courtesies and information received from Mr. L. W. Thayer. Mr. J. B. Hadley assisted the writer in logging drill-core.

STRATIGRAPHY

Other than those of Quaternary age, the rocks exposed within the area fall within two major divisions, namely the flat-lying beds of Tertiary age, and the steeply dipping, moderately metamorphosed rocks of probable Jurassic age. The Tertiary strata lie unconformably on the older rocks, which are intensely weathered adjacent to this contact.

The Tertiary rocks, which cover much of the northern half of the area, have been correlated by Turner [2] with the Ione formation. They include ill-sorted conglomerate cemented with red clay; gravel with white quartz, felsite, fine-grained sandstone, and other pebbles; limonite-cemented sandstone; pale-gray, fine-grained sandstone and siltstone; white and buff mudstone; and limonite rock. To the south these strata are replaced by white quartz gravels, generally auriferous, which Turner [3] considered to have been deposited by rivers flowing into the Ione sea.

The older rocks are predominantly volcanics, and on the basis of their lithology they are tentatively correlated with the Amador group [4] of Upper and possibly Middle Jurassic age. Within the area this group is a sequence of felsitic, dacitic, andesitic, and basaltic pyroclastics and flows, with the intermediate and felsic rocks predominating; these rocks are metamorphosed to low-rank schists and greenstone. They form a portion of the stratigraphic section described in the paper on the Penn mine area.

The local stratigraphic section is thought to be overturned (that is, its top is to the west), because of the sequence relation of the volcanic rocks to the younger Mariposa slate lying to the westward, because of the lithologic similarities of these volcanics to those of the type section of

[2] Turner, H. W., U. S. Geol. Survey Geol. Atlas, Jackson folio (no. 11), 1894.
[3] Turner, H. W., op. cit.
[4] Taliaferro, N. L., Geologic history and correlation of the Jurassic of southwestern Oregon and California: Geol. Soc. America Bull., vol. 53, pp. 89-90, 1942.

the Amador group, and because graded bedding observed in the Penn mine area indicates tops to the west.

Because there is a dearth of good exposures in most parts of the Grayhouse area, no attempt has been made to differentiate stratigraphic units within the Amador (?) group, except a prominent metabasalt zone cropping out in the eastern part of the area. This zone ranges in thickness from 400 to 500 feet. It is made up of medium- to dark-green chlorite and chlorite-epidote schists and greenstones, probably derived from basaltic lavas. These rocks weather to shades of darker-green or brown except immediately under the Tertiary beds where they are weathered to pale-green or brown, buff, or white. In many places abundant flecks of dark-green chlorite are present, which may represent former phenocrysts. Locally amygdules of quartz or calcite are abundant.

Much of this metabasalt zone shows well-developed pillow structure, with interstitial cherty material, red jasper, or epidote-quartz rock. Gash jointing on the surfaces of the pillows is common. The pillows are generally flattened parallel to the schistosity, and in extreme cases the original structures are almost entirely obliterated.

Zones of crystal tuff have been differentiated at several places. They are made up of light-colored, commonly feldspathic tuffs, containing subhedral quartz crystals and fragments of quartz. In places stratification is evident. These zones are generally quite local in their extent.

INTRUSIVE ROCKS

The intrusive rocks present within the area are quartz porphyry and felsite, similar to those occurring in the adjoining Penn mine area. For detailed descriptions of these rocks the reader is referred to the paper on the Penn mine.

These intrusive rocks have a schistosity, in many places strongly developed, that is in general parallel to the foliation of the enclosing volcanic rocks, which would indicate they antedate the regional orogeny. It is possible they are slightly later manifestations of Amador vulcanism, for the fine-grained character of the intrusive felsite suggests emplacement at shallow depth, before a thick cover had accumulated.

ROCK ALTERATION AND QUARTZ VEINS

Hydrothermal Alteration

Crossing the Grayhouse area in a direction approximately parallel to the strike of the foliation is a belt characterized by discontinuous zones and lenticular areas of sericitization, silicification, and pyritization. The southernmost of these zones is the northern continuation of the Hecla alteration zone of the Penn mine area. The zones to the northward, in a general way, are offset en echelon to the eastward, similar in a certain degree to the pattern of the Jean alteration zone of the Penn mine area.

Sericitization is the most widespread of these types of alteration, and in most cases it seems to be restricted to felsitic volcanic rocks or to quartz porphyry. Transition from unaltered to altered rock is gradual, and the more intensely altered rock generally has the more strongly developed schistosity. Locally silicification becomes important, the introduced silica being whitish cryptocrystalline quartz developed as folia parallel to the schistosity.

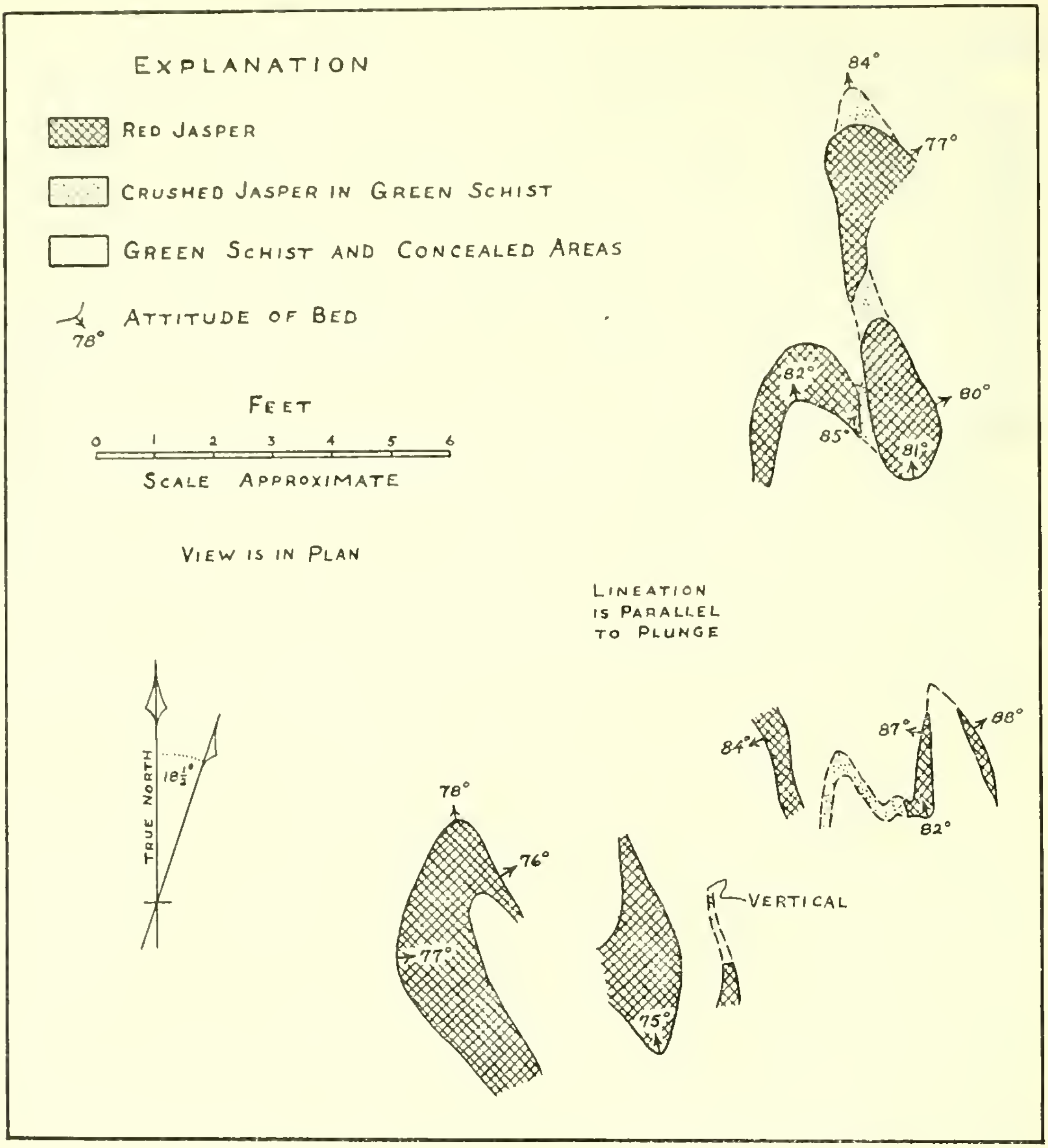

Fig. 1. Field sketch of folds in Barnett Gulch, Grayhouse area, Amador County, California.

At certain places within these alteration zones bands of schist a fraction of an inch to several feet thick are impregnated with disseminated pyrite. Gossans have developed on some of them. The locations of the gossans are shown on the map.

At two localities, both indicated on plate 33, the weathered green schists contain abundant nodules and streaks of limonite. Because in both cases the present surface lies only a short distance beneath the unconformity developed during a period of intense weathering, before deposition of the Tertiary deposits, it seems possible that the limonite has resulted from the oxidation of pyrite, which may have an origin distinct from that occurring within the alteration zones.

The general relations between the rock types and alteration zones of the Grayhouse area are similar to those of the Penn mine area to the south.

Quartz Veins

Veins of milky quartz are common in the area, especially within or adjacent to the alteration zones. In general they strike approximately parallel to the schistosity of the enclosing rock, and have a steep dip to either the eastward or the westward. The veins range in thickness from a fraction of an inch to 4 feet, and the larger ones commonly show a pronounced transverse parting or jointing. Small amounts of epidote and calcite are present in some of these veins.

STRUCTURE

Schistosity and Lineation

Schistosity can be discerned in almost all the types of rocks of Jurassic age. In general it has a northwest strike, and in most places a steep easterly dip. In the northernmost part of the area westerly dips are not uncommon. Bedding, which was observed only in the southern part of the area, may dip less steeply or more steeply than the schistosity. Lineation developed on schistosity has a plunge[5] close to the dip direction.

Folds

Small folds in beds were observed in Barnett Gulch about 450 feet upstream from its mouth. These folds, illustrated in figure 1, are delineated by red jasper beds in green schist derived from pyroclastics. The folds, which are developed in steeply dipping beds, have amplitudes ranging from 1 to 6 feet and plunge northward at angles ranging from 78° to 84°. Most of them are overturned, with their axial planes dipping eastward at high angles, approximately parallel to the plunge of the folds.

It seems likely that other folds of similar character are present elsewhere in the area, but probably have not been recognized because of lack of favorable exposures.

Faults

Three types of faults were observed within the area. They are (1) east-dipping, high-angle strike faults; (2) relatively low-angle reverse faults that strike between N. 50° W. and north, and dip east 25°-50°; and (3) high-angle faults that strike northeastward. These types are

[5] Plunge, as here used, is defined as the vertical angle between a horizontal plane and the line of maximum elongation.

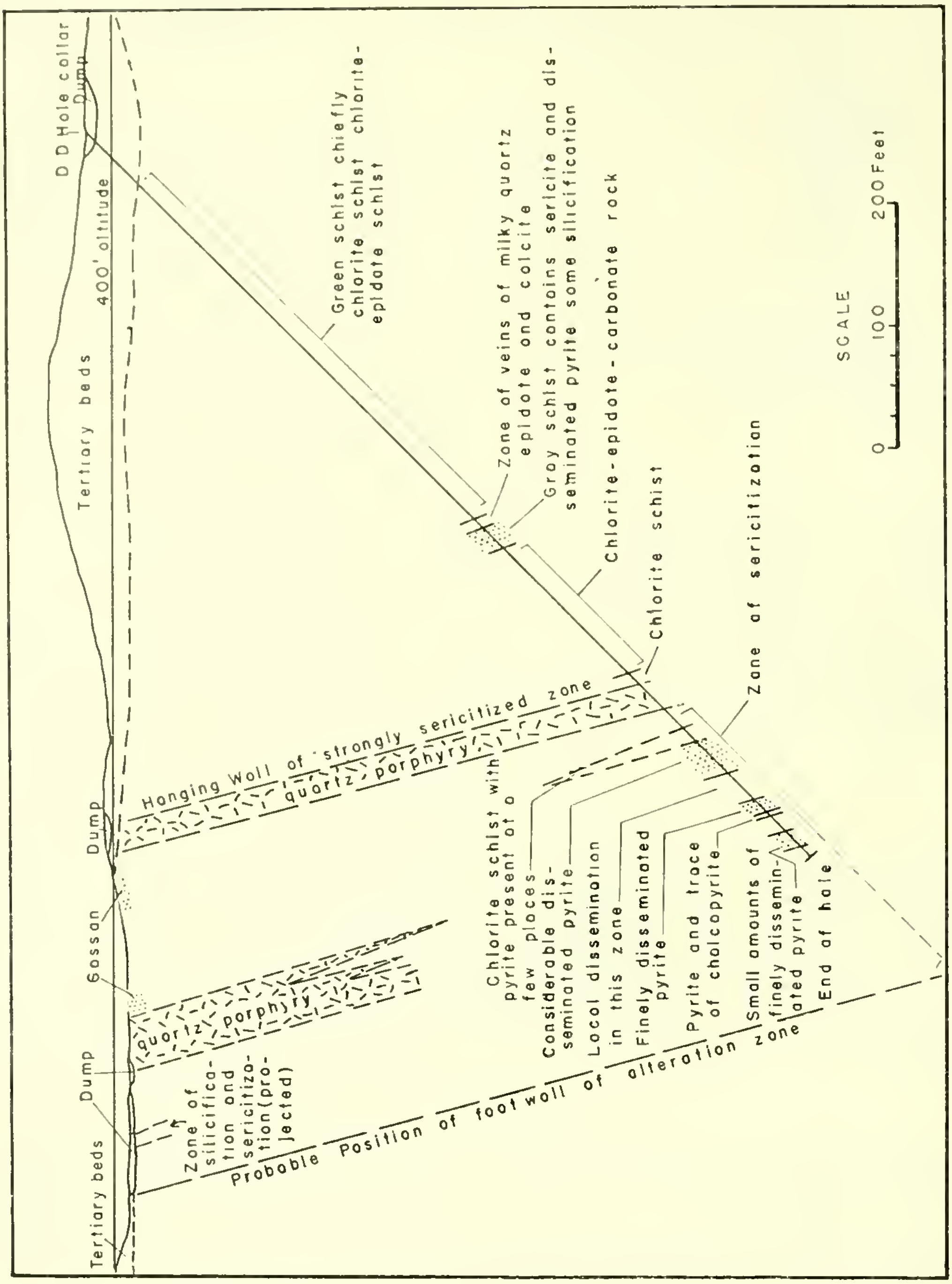

FIG. 2. Grayhouse diamond-drill hole, Amador County, California; hole logged by G. R. Heyl and J. B. Hadley.

similar to those observed in the Penn mine area to the south, where the first two types have been significant in the control of ore deposition. The low-angle reverse faults, generally with small apparent displacements, are particularly numerous within the alteration zones; in most cases reverse drag on the schistosity is quite evident.

MINERALIZATION

The gossans observed in the area are in every case located within the zones of alteration. Their position is indicated on the map (pl. 33). Two of the more prominent areas of gossan are those exposed in the inlier of schist from 600 to 700 feet westward of the collar of the Bureau of Mines diamond-drill hole, and the one in Barnett Gulch about 350 feet upstream from its mouth.

In color the gossans range from shades of red brown to dark brown. By analogy with the neighboring Penn mine gossans, together with the cubical character of many of the voids, this color suggests that they were derived from predominantly pyritic material.

Judging from the composition of the mine dump, the Grayhouse shaft and connecting workings have apparently explored one of the more heavily mineralized portions of the alteration zones. The dump is made up mainly of sericite schist, some of it carrying disseminated pyrite, together with lesser amounts of strongly silicified schist that carries abundant disseminated pyrite. Also present in small amounts are pieces of heavy sulphides, consisting of an intimate mixture of pyrite, sphalerite, and chalcopyrite; a selected sample of this material, collected by L. W. Thayer and assayed by Abbot A. Hanks, Inc., of San Francisco, contained 7.83 percent copper, 14.04 percent zinc, 0.22 of an ounce of gold to the ton, and 11.48 ounces of silver to the ton.[6] A few specimens of tetrahedrite in milky quartz can be found in the dump.

L. W. Thayer[7] states that in driving the shafts, drifts, and crosscuts of the mine, an occasional nodule of heavy sulphide was encountered. According to Aubury,[8] in this mine "the ore is sulphide below and carbonate above."

In 1943 the U. S. Bureau of Mines drilled an 833-foot hole at an inclination of 45° under one of the more prominent gossans in the northern part of the area; a section drawn through this hole accompanies this report (fig. 2).

This diamond-drill hole intersected the hanging wall of the alteration zone at 635 feet, and did not extend to the footwall of the zone. It penetrated several intervals of schist carrying disseminated pyrite, and a one-foot thickness (at 787-788 feet) of nonschistose, siliceous rock containing disseminated pyrite and traces of chalcopyrite. No commercial ore was intersected by the hole.

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[6] Thayer, L. W., Personal communication.
[7] Thayer, L. W., Personal communication.
[8] Aubury, L. E., The copper resources of California: California Min. Bur. Bull. 50, p. 225, 1908.

ORE DEPOSITS OF COPPEROPOLIS, CALAVERAS COUNTY, CALIFORNIA *

By George R. Heyl **

OUTLINE OF REPORT

ILLUSTRATIONS

ABSTRACT

The Copperopolis mines have been among the significant producers of copper in California since 1861 with a total production of about 72 million pounds of copper. The mines include the North Keystone mine, second largest copper producer in the state during World War II, and the Keystone-Union mine, a major producer in earlier years.

The area is underlain by volcanic and argillaceous rocks of probable Jurassic age, which have been metamorphosed to green schists, greenstones, and slates. Intruded into the metavolcanics and slates are dikes and lenses of granodiorite, diorite, hornblendite, grabbro, and serpentine.

A prominent fault zone trends northwest through the area. This zone served as the locus of hydrothermal alteration and mineralization. A discontinuous belt of intense chloritization within this fault zone contains the ore bodies, which are lenticular sulphide replacement deposits. The ore consists of veinlets of chalcopyrite and pyrite in chloritized rock. Zones of disseminated coarse grains of pyrite form envelopes around the ore bodies. These envelopes are useful guides to their location. Granodiorite, even where sheared and chloritized, appears to have been a less favorable environment for penetration and replacement by copper-bearing solutions than were slate and schist.

The Copperopolis district is one of the most favorable areas in the Foothill copper-zinc belt for the finding of additional copper reserves.

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INTRODUCTION

Location and Accessibility

Within and adjacent to the village of Copperopolis (pl. 1), in western Calaveras County, is a group of mines that have been among the significant contributors to the copper production of California since 1861. These include the North Keystone mine, which recently has been the second-largest copper producer in the state, and the Keystone-Union, a major producer in earlier years, representing a consolidation of the original Union and Keystone properties. Southeast of these is the Empire mine, a smaller development whose production record is not available, and two prospects known as the McCarty and the Calaveras mines. All of these are developed in a strongly mineralized belt designated the Reed lode, which passes through the town of Copperopolis and trends northwest.

Copperopolis is readily accessible by two all-weather, hard-surface roads, State Highway 4 connecting Stockton with Angels Camp, and the county road running from O'Byrnes Ferry to Milton. The closest rail shipping points are Farmington, about 20 miles west, and Kentucky House, about 15 miles north.

Topography and Drainage

The area is one of mature topography, characterized by ridges and valleys trending northwest, reflecting the structural grain of the country. The village lies at an altitude of 950 to 1,000 feet, in a moderately broad valley bounded by prominent ridges on either side. The maximum relief of the area within a mile from the town is approximately 1,000 feet, but the average relief is considerably less.

The local area is drained by Copper and Penny Creeks, small subsequent tributaries of Black Creek, which flows southeast to the Stanislaus River. The current youthful erosion stage that characterizes the master streams of the west slope of the Sierra Nevada has not yet worked headward as far as the immediate vicinity of the mines and village. Consequently, the streams and valleys at Copperopolis are in a mature stage of erosion, representing an earlier cycle, and very probably an inheritance of the late Tertiary or earliest Quaternary topography.

History and Production

The Reed lode at Copperopolis was discovered in June 1861, and during the following month a group of local residents headed by the principal discoverer, W. R. Reed, after whom the lode is named, located along this mineralized belt 11,250 feet of claims which included the Calaveras, the Empire, the Union, the Keystone, and the Consolidated. As soon as the importance of the discovery became known, a rush of prospectors started and within a few days claims were staked off extending nearly 20 miles northwest and southeast along the regional strike (pl. 34). This activity further stimulated the wave of intense prospecting that had been started in the region by Hiram Hughes' discovery of the Quail Hill gossan in November 1860. As a consequence, the thousands of persons attracted to the area became familiar with the general appearance of copper ores, and carried this knowledge to other areas in the state where many gossans and deposits, formerly not recognized, soon developed into active mines. Thus the copper mining industry of California received its first impetus.

As a result of the rush to the Reed lode, Copperopolis was founded in September 1861, and less than 2 years afterward the town had grown to a thriving community of nearly 2,000 people, supported primarily by copper mining and related pursuits. The Union mine was a profitable enterprise from the very beginning of mining operations, and by the fall of 1866 had been developed to a depth of 500 feet. It was then the largest copper mine in the state, and had yielded more than half the total California production for the years 1861-66. The adjoining Keystone mine, by 1867, was developed to a depth of 552 feet, but its recorded production for the 6 previous years was only about a tenth of that of the Union mine. The Empire mine likewise underwent considerable development during this period, but on most of the other claims in the district the amount of underground exploration was small.

In these early days the ore was hauled by wagon to Stockton, from there was shipped by river-boat to San Francisco, whence it was exported to Atlantic Coast ports or to Swansea, Wales. Shipping costs were high, causing all ores of less than 10 percent to be valueless. Attempts to utilize lower-grade ores were made by the erection of a smelter at the Union mine, and a concentrating plant at the Keystone mine, but in neither case were these operations profitable. The average tenor of ore shipped from the Union mine did not exceed 15 percent copper, and that from the Keystone averaged about 1 percent higher. By roasting over wood fires, the tenor of some lower-grade material was increased to that of commercial grade.[1]

In 1867 the mines closed down in consequence of a fall in the price of copper, and a marked increase in mining and shipping costs. The Union mine was active during only part of that year, and the Keystone, Empire, Consolidated, and Inimitable properties were not worked after the early spring of the year.[2] The construction of the Stockton & Copperopolis Railroad, completed from Stockton to Milton, was discontinued when the mines closed.[3]

By 1887 the Union and Keystone mines were held under one ownership by a group of Boston men. These properties had been idle since 1867, but during 1887 and 1888 they were unwatered.[4] This was followed by a second period of activity, in which the Union shaft was sunk to 600 feet, a 100-ton Orford furnace was erected, and some high-grade matte was produced. The properties were shut down in 1892, and remained idle until 1901 when unwatering was again started.[5]

The Keystone-Union mine, operated as a unit, was active in the years 1902-09, 1911-20, 1923-27, and 1929-30. During the earliest of these intervals the ore was treated by leaching and by direct smelting. Since 1911 the treatment has been either direct smelting or concentration and smelt-

[1] Browne, J. R., Mineral resources of the States and Territories west of the Rocky Mountains for 1866, pp. 138-169, 1867.
[2] Browne, J. R., Mineral resources of the States and Territories west of the Rocky Mountains for 1867, pp. 207-219, 1868.
[3] Raymond, R. W., Statistics of mines and mining in the States and Territories west of the Rocky Mountains for 1871, pp. 47-48, 1872.
[4] Irelan, W., Jr., Eighth Annual Report of the State Mineralogist: California Min. Bur. Rept. 8, pp. 150-152, 1888.
[5] Reid, J. A., The ore deposits of Copperopolis, Calaveras County, California: Econ. Geology, vol. 2, p. 382, 1907.

Table 1. Production data, Copperopolis mines

Period	Material treated		Gold (ounces)	Silver (ounces)	Copper (pounds)	Producing property
	Ore (short tons)	Old tailings (short tons)				
1861-1866	[1]				[2]	Empire mine
	6,794				*2,174,135	Keystone mine
	67,172				*20,151,569	Union mine
1867	[1]				[2]	Empire mine
	[1]				[2]	Keystone mine
	4,191				*1,257,428	Union mine
1868-1886	[3]				[3]	
1887-1889	6,000				*360,000	Union mine
1890-1892	[1]				[2]	Keystone and Union mines
1893-1901	[3]				[3]	
1902	[1]	[1]			50,353	Keystone-Union mine
1903	[1]	[1]			50,000	Keystone-Union mine
1904	[1]	[1]			50,000	Keystone-Union mine
1905	[1]	[1]			30,464	Keystone-Union mine
1906	9,470				1,457,890	Keystone-Union mine
1907	10,707				1,112,550	Keystone-Union mine
1908	[1]				21,038	Keystone-Union mine
1909	[1]	[1]			24,977	Keystone-Union mine
1910	[3]	[3]	[3]	[3]	[3]	
1911	700	[1]			19,464	Keystone-Union mine
1912	4,196	[1]	1	31	755,200	Keystone-Union mine
1913	4,210		41	1,949	1,052,569	Keystone-Union mine
1914	800		8	425	269,985	Keystone-Union mine
1915	1,075		6	37	519,126	Keystone-Union mine

1916	59,621				1,710,625	Keystone-Union mine
1917	150,416				3,923,883	Keystone-Union mine
1918	129,271				3,492,626	Keystone-Union mine
1919	51,088			874	1,177,698	Keystone-Union mine
1920	53,399			2,340	2,039,045	Keystone-Union mine
1921-1922	3	3	3	3	3	
1923	35,957			1,464	1,436,326	Keystone-Union mine
1924	65,306		32	4,122	4,708,820	Keystone-Union mine
1925	113,165		62	4,730	4,687,607	Keystone-Union mine
1926	122,573		104	5,298	5,231,750	Keystone-Union mine
1927	6,872		9	502	451,078	Keystone-Union mine
1928	3		3	3	3	
1929	23,034		1	1,389	1,162,896	Keystone-Union mine
1930	37,340			1,982	1,897,238	Keystone-Union mine
1931-1941	3	3	3	3	3	
1942	12,208		15	602	542,380	North Keystone mine
1943	71,004		81	3,409	3,978,872	North Keystone mine
1944	98,578		54	3,195	3,836,700	North Keystone mine
		220,282	25	1,485	536,184	Keystone-Union mine
1945	43,759		25	1,347	1,640,800	North Keystone mine
		207,000	18	1,758	605,200	Keystone-Union mine
1946		64,558	10	559	182,407	Keystone-Union mine
Total	1,188,906	491,840	492	37,498	72,598,883	

[1] Tonnage not reported.
[2] Amount not reported.
[3] No production reported.
* Estimate by writer.

NOTE: Production figures for the Copperopolis district for the years since 1901 have been generously supplied by the U. S. Bureau of Mines, through the courtesy of Messrs. C. W. Merrill and A. L. Ransome.

ing. In August 1930, in response to a marked decrease in the price of copper, the mine was shut down; it has not reopened since that date. During 1944-46 tailings from earlier operations were reworked for their copper content.

The North Keystone mine is developed in the northern end of the old Keystone claim. Its early history is obscure. In 1906 this mine lay idle; its main shaft was then reported to be about 600 feet deep.[6] The mine was unwatered for examination in 1929-30, and a small amount of exploration was done on various levels, including the 675 level, then the deepest.[7] With the closing of the adjacent Keystone-Union this work ceased.

The North Keystone mine was again unwatered in 1942, and production of ore began in the fall of that year. It continued to operate until the summer of 1945, by which time it had been developed to the 1075 level. During these years it was the second-largest producer of copper in California.

A summary of the known production of the Copperopolis mines is given in table 1.

Field Work and Acknowledgments

Field work by the U. S. Geological Survey at Copperopolis, including both surface and underground mapping, was begun early in 1943, and was continued at various intervals until the summer of 1945. Surface mapping was done by plane-table and compass traverses; underground mapping was carried on by use of tape, tripod, and Brunton compass. A portion of the surface area was surveyed with a Gurley dip needle. In the North Keystone mine, some engineering data supplied by the staff of the Keystone Copper Corporation were used in adjusting the level maps.

It is a pleasure to acknowledge the able assistance of the following members of the Geological Survey, who have contributed materially in the work: M. W. Cox, J. B. Hadley, G. L. Quick, and M. H. Staatz, who helped with various phases of the surface or underground mapping; M. W. Cox, J. H. Eric, and D. C. Wyant, who assisted in the dip needle survey; and J. B. Hadley who aided in organizing much of the material relating to the North Keystone and Keystone-Union mines. Hearty thanks are due R. S. Cannon, Jr., and G. H. Espenshade, and M. H. Krieger for valued advice and criticism.

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GENERAL GEOLOGY

The region in the vicinity of Copperopolis is underlain by a sequence of volcanic and argillaceous rocks of probable Jurassic age; these have been transformed by low-grade metamorphism to green schists, green-

[6] Reid, J. A., op. cit., pp. 402-403.
[7] Kirk, R. L., personal communication.

stones, and slates. The volcanic rocks, which make up the greater part of the sequence, are chiefly pyroclastics, including coarse- and fine-bedded tuffs, lapilli-tuffs, and volcanic breccias. On the basis of their lithology, they are tentatively correlated with the Amador group (Jurassic).

The narrow belt of blue-gray slate that crops out in the village of Copperopolis and is immediately east of the Keystone-Discovery and South Union shafts, and the zone of slate that extends south from the Copperopolis reservoir, were correlated by Reid [8] with the Mariposa formation (Jurassic). He considered them the southward extension of the belt of Mariposa slates mapped by Turner [9] between Harmon Peak and Towers in the Jackson quadrangle near its southern edge. On the other hand, Taliaferro [10] in his regional mapping of the Copperopolis quadrangle has correlated these slate zones with lithologically similar rocks within the Amador group.

Intruded into this series of slates and metavolcanic rocks are dikes, small lenses, and larger elongate bodies more or less concordant with foliation or bedding of the enclosing rocks. The intrusions include granodiorite, diorite, quartz diorite, hornblendite, gabbro, and serpentine. Very commonly the intrusive rocks show effects of shearing and crushing, and in some places a marked schistosity is developed within them.

The serpentine in the area forms some moderately large bodies, such as those southwest of the Union and Empire shafts, as well as smaller lenses and dikes. Generally, the serpentine bodies are much jointed and slickensided, and along much of their margins grade into talc schist. By far the commonest type of serpentine is dark green to almost black, though there is a pale-green variety. The rock is typically aphanitic, and under the microscope shows both ''lattice'' and ''knitted'' structure. In places disseminated chromite is present.

The gabbro in the area generally has been thoroughly saussuritized It is a medium-grained, dark greenish-gray to white rock, the latter color being characteristic of the more thoroughly altered types. Megascopically, greenish-gray to white plagioclase is readily discerned, with much diallage having distinctive pearly luster and foliated structure. Under the microscope the pyroxene is colorless, with or without schiller inclusions, and is generally partially chloritized, and, less commonly, uralitized. Clinoenstatite is present in a few specimens. The plagioclase is altered to a mixture of albite, sericite, epidote, zoisite or clinozoisite, chlorite, and, in some cases, carbonate. Apatite and leucoxene are present as accessory minerals. Individual grains in the rock in many places exhibit distortion and fracturing, a result of post-solidification deformation.

Granodiorite crops out as several intrusions of moderate size in the central and northern parts of the area; it is also present in the North Keystone mine and the Empire tunnel. It is a medium- to coarse-grained, phanerocrystalline, greenish-gray to whitish-gray rock that weathers to shades of gray or buff. Readily made out in the hand specimen are quartz, white feldspar, and chlorite. Under the microscope the feldspar is seen to include both plagioclase and orthoclase, with the former in greater amount. The plagioclase is sodic oligoclase or albite. Apatite and

[8] Reid, J. A., op. cit., pp. 385-386.
[9] Turner, H. W., U. S. Geol. Survey, Geol. Atlas, Jackson folio (no. 11), 1895.
[10] Taliaferro, N. L., personal communication.

sphene are present as accessories. Chlorite is the most abundant ferromagnesian mineral, and at least in part is derived from hornblende and biotite. Epidote, sericite, calcite, and leucoxene are other important alteration products. In some places quartz-albite veinlets cut the rock; in others, quartz-calcite-epidote veinlets are abundant. In the vicinity of the ore deposits, introduced pyrite is common, and in some places chalcopyrite is also present as veinlets or disseminated grains.

The granodiorite shows many effects of cataclastic deformation, such as wide and minute zones of granulation throughout the rock, the crushing of quartz grains, and the sharp bending or microfaulting of plagioclase twinning bars. Chloritization has apparently favored these deformed areas. In certain zones of intense shearing the crushed granodiorite has been transformed to chlorite-sericite-quartz augen schist.

The regional strike of the rocks in the vicinity of Copperopolis is about N. 42° W., and, in general, the schistosity and cleavage, as well as the bedding, dip steeply east. In most places where stratification can be observed, it is closely parallel to the foliation of the rock; locally, however, as on the hillside 500 feet southwest of the Keystone-Discovery shaft, bedding and schistosity are quite divergent.

A prominent fault zone, approximately parallel to the regional strike, extends through the area. It includes at least two major faults, both dipping eastward at high angles, and arranged en echelon. The northern of these has been styled the Footwall fault, because it forms the footwall of the ore zone in the North Keystone mine;[11] the southern one is designated the Calaveras fault from the shaft at which it is best exposed.

The pattern of outcrop of the formations as shown on the geologic map (pl. 35) is suggestive of folding. Direct evidence of folding is seen in the attitudes of beds in the vicinity of the diorite intrusion near the edge of the area southwest of the Keystone-Union mine. The beds immediately north of this intrusion form an anticline plunging steeply southward; those to the south reflect several small folds, all plunging steeply to the south. Whether the slate belt that terminates about 1,300 feet southeast of this intrusion represents the core of a tightly folded syncline is not clear from field evidence, though its position with respect to the exposed folds is suggestive of this. It is quite possible that the outcrop pattern of other slate belts in the area may indicate isoclinal folds.

ALTERATION PROCESSES ASSOCIATED WITH COPPER MINERALIZATION

The major fault zone extending through the area has served as a locus of hydrothermal alteration and mineralization. Following this fault zone is a discontinuous belt of intense chloritization, which has been superimposed on the regionally metamorphosed volcanic, sedimentary, and intrusive rocks. This belt, in which the copper deposits occur as lenticular bodies of chalcopyrite and pyrite, reaches a maximum width of 300 feet in the south-central part of the area, and its northern and southern ends are almost 9,000 feet apart. In detail, it crosscuts stratigraphic and lithologic contacts, the chloritization affecting slate,

[11] Heyl, G. R., Hadley, J. B., and Quick, G. L., Map of the North Keystone mine, Calaveras County, California: U. S. Geol. Survey, Strategic Minerals Investigations, 1943; Strategic Minerals Investigations, Prelim. Maps 3-183, North Keystone mine, Copperopolis, California, 1945.

metavolcanic schists, granodiorite, and on a small scale, hornblendite and serpentine.

The chlorite of this alteration zone is dark green, generally somewhat lustrous. In thin section it is pale green and pleochroic. The mineral has a birefringence of 0.003, as estimated from the interference color, and positive elongation (length-slow). C. S. Ross[12] determined the mean index of refraction to be approximately 1.64, indicating a high iron content. According to the Winchell classification,[13] it would be aphrosiderite with a composition approaching that of the daphnite ($H_4Fe_2Al_2SiO_9$) molecule.

As an accompaniment to the copper mineralization, sericitization has been a relatively minor process. There is no evidence that the sericite present as small flakes in granodiorite and in many of the feldspathic metavolcanic rocks of the region is related to the copper mineralization, for it is distributed through these rocks irrespective of their proximity to the copper deposits. Within the mineralized zone, however, intense sericitization is evident in some places where shearing and crushing have been extreme. Relatively coarse folia of sericite are developed, and are generally associated with white quartz and abundant disseminated pyrite. Because this mineral association has been observed only in the immediate vicinity of the copper ore bodies, most frequently in the hanging wall, it is thought to be definitely related to the copper mineralization.

Pyrite is common in the zone of mineralization. This mineral, generally disseminated as coarse grains, occurs in envelopes of strongly pyritized rock around the copper ore bodies. It is particularly abundant adjacent to their tapering ends. Away from these bodies it is more sparsely distributed in the country rock, but is present to a certain degree throughout a wide area in the chloritized zone. This pyritization is genetically related to the copper mineralization, pyrite and chalcopyrite being intimately associated in the deposits, though some of the pyrite was definitely introduced earlier than the chalcopyrite.

Finely disseminated magnetite has been introduced into the gouge and bounding walls of many of the fault zones in the mineralized belt. It is generally associated with talc, a mineral characteristically developed along major faults in the area. The magnetite may be present as minute octahedra, and may be so abundant as to give the talc a bluish-gray or black hue.

MAGNETIC ANOMALIES IN THE AREA

To aid in determining the geologic structure, and particularly, in locating more precisely the trace and possible extensions of the Footwall and other faults in the district, the area was surveyed with a Gurley dip needle. To serve as a base for this, a grid was laid out and tied in with previously established points in the field. This grid consisted of 723 points, made up of 67 profiles normal to the over-all strike of the geologic units. In general, these points were 100 feet apart along the strike and 50 feet apart across the strike, though locally, where conditions warranted it, points were established at half these intervals. Dip needle readings were taken at each of these points, and from these data a regional

[12] Ross, C. S., Personal communication, May 28, 1946.
[13] Winchell, A. N., Elements of optical mineralogy, pt. 2, Description of minerals, pp. 374-376, New York, John Wiley & Sons, 1927.

or normal reading of the instrument was determined. The magnetic anomalies or the deviations from this normal reading were then plotted in their respective positions, and contoured (pl. 36).

The pattern shown by the dip-needle survey indicates that there are appreciable differences in the magnetic susceptibility of the rocks in the area covered. These are, of course, reflected by the shape and relief of the anomaly surface defined by the contours. The relation between the anomaly pattern and the areal geology can be brought out by superimposing the dip-needle survey on the geologic map, the roads in each being used as convenient reference points. When this is done the essential parallelism of the anomaly trends and the geological units is readily shown. In general, the long axes of the "highs" and "lows" strike close to N. 42° W., which approximates the regional strike.

In greater detail, several pertinent relationships can be seen. The Footwall fault is marked by a series of elongate "highs," trending with the strike; in places the steeper southwest sides of these "highs" indicate the eastward dip of the fault. The elongate "high" beginning about 400 feet southeast of the South Union shaft possibly reflects the extension of this fault for an additional 600 feet to the south beyond its mapped position; its shape may also reflect two bends in the detailed pattern of the fault. Other bends in the trace of this fault are indicated along its extent south of the Keystone Discovery shaft.

The second major fault line, the Calaveras fault, about 125 feet southwest of the Empire shaft, is only meagerly reflected in the anomaly pattern, but this may be due in part to the large amount of magnetic debris lying along its trace near the southern edge of the area.

In general, the areas of intense chloritization are reflected by broad "highs," and the large serpentine body in the central part of the area is characterized by abrupt and extreme "highs." The smaller serpentine bodies in the southern part of the area apparently have had little effect on the anomaly surface as determined. The sharp "low" about 100 feet northeast of the Keystone Discovery shaft is in part explained by the presence of a large transformer near its north end, but its trend and relation to the over-all pattern probably mean it has some geologic significance as well. In summary it can be said that the dip-needle survey shows that the intensely chloritized rock of the district, the magnetite-bearing talcose gouge of the Footwall fault, and at least part of the serpentine differ enough in their magnetic susceptibilities to register appreciable anomalies, the pattern of which serves as a distinct aid in the interpretation of the geologic structure.

THE COPPEROPOLIS MINES

The most important mines and prospects at Copperopolis are, from north to south, the North Keystone mine, the Keystone-Union mine, the Empire mine, and the McCarty and Calaveras prospects. Of these, the Keystone-Union and the North Keystone have been the most active mines and the major producers in the district.

In recent years the North Keystone has been the only one accessible for extensive underground examination, and consequently most of the conclusions relating to the geology of the ore bodies have been based on observations made in this mine. However, to supplement the study of the ore deposits as much as possible, assay sheets and maps of other mines in the district, and several accessible shallow openings, as the Empire tunnel and the McCarty shaft, have been studied in detail.

North Keystone Mine

The North Keystone mine is at the north edge of Copperopolis, and west of State Highway No. 4, which serves as the main street of the village. The mine consists of a three-compartment vertical shaft, 1,115 feet deep, with six levels at approximately 150, 375, 525, 675, 875, and 1,075 feet (pl. 37). The collar of the shaft is in the hanging wall; the shaft passes through the mineralized zone at the 375 level, below which it is in the footwall.

In the vicinity of the mine, slate and metavolcanic rocks of probable Jurassic age crop out; these strike northwest and the cleavage, schistosity, and bedding, of which the latter is seen but rarely, dip steeply northeast. The metavolcanics predominate, and include pale-green spotted schist and greenstone derived from andesitic and dacitic rocks, slaty tuffs and schistose pyroclastics, bedded hornstone and volcanic breccia. The slate is typically argillaceous and dark blue gray, weathering to lighter shades of gray or to buff.

Also cropping out in this area are three intrusions of moderate size, and a dozen or more smaller intrusions, mainly dikes more or less concordant with the foliation of the enclosing rocks. East of the mine is an elongate body of dark-green serpentine, in the southern part of which is an oval-shaped area of saussuritized gabbro. About 1,000 feet north of the mine is an irregularly shaped body of hornblendite, adjacent to which are several dikes of hornblendite breccia. Smaller dikes of the area include serpentine, hornblendite, diorite, and granodiorite.

The most significant intrusion, insofar as the local distribution of the copper mineralization is concerned, is the large body of granodiorite that extends southward from the northwest edge of the area and on the surface fingers out 150 feet west of the shaft collar. Underground this intrusion widens and extends a greater distance to the south, as shown by its extent in the mine (pl. 37), and by core-drill holes located north of the mine. This rock is older than the copper deposits, for in places it is impregnated with chalcopyrite as well as pyrite. Even where sheared, crushed, and thoroughly chloritized, however, it has afforded a less favorable environment for replacement by copper-bearing solutions than the contiguous chloritized slate and schist; therefore, where granodiorite occupies a proportionally large width in the belt of chloritization, the copper deposits, if present, are generally lean and in many places give way to heavy streaks of pyrite or virtually barren rock.

The Footwall fault crops out about 175 feet southwest of the shaft collar, and dips 67° northeastward. It is also exposed in the short adit 250 feet west of the shaft. This fault is a prominent feature in the mine, forming the footwall of the zone of chloritization that contains the ore bodies. It generally has a well-developed gouge, 1 to 20 inches wide, though locally the zone of gouge and crushed rock may reach a width as great as 8 feet. In many places the gouge is talcose, and contains disseminated magnetite. Near the north end of the 375 level, undisturbed veinlets of magnetite carrying some chalcopyrite were present in the gouge, and a few feet from this several partially rounded, abraded, and slickensided nodules, or "niggerheads," of chalcopyrite were uncovered in the gouge. In the 1075 level narrow veinlets of chalcopyrite and pyrite penetrate the gouge, some of it as fingerlike extensions from the mineralized zone contiguous on the east. Slickensided chalcopyrite is frequently seen adjacent to the Footwall fault. These facts indicate the fault is a pre-ore structure along which some movement occurred after the introduction of sulphides.

Sigmoid partings in the gouge of this fault, observed at several places in the mine, are so oriented as to indicate that the hanging wall moved downward and southward relative to the footwall. This would suggest that the latest movement on the fault was normal, with a diagonal net slip. The direction of earlier movement is not known.

Detailed mapping underground shows that the attitude of the fault surface is not uniform, but that the fault has minor, though appreciable, variations in both strike and dip. The changes in strike range to 15°, and are best illustrated by the maps of the 375, 525, and 675 levels (pl. 37). The extreme range of dip is from 45° to 78°, though in most places the dip readings fall between 62° and 72°. Adjacent to the Footwall fault there are several subsidiary faults, and at least two bifurcations, one at the south end of the mine and one in its northern portion.

This fault forms the footwall of the zone of chloritization that contains the ore bodies. On the surface, about 350 feet northwest of the shaft collar, the zone reaches a maximum width of 93 feet; underground, the greatest observed width is approximately 60 feet. It narrows toward the south end of the mine, and on the surface, at least, pinches out. It is therefore not continuous with the similar wider belt of chloritization at the Keystone-Union and Empire mines. Northward from the mine it may be followed about 1,750 feet, where it pinches out.

The ore bodies are sulphide replacement deposits of elongate lenticular form with no sharply defined walls. These lenses lie parallel to the foliation of the enclosing rock, with their major axis or greatest dimension approximately parallel to the dip. In detail, they are composed of innumerable interconnected, anastomosing veinlets of chalcopyrite and pyrite in chloritized slate, schist, and, to a lesser extent, granodiorite. The veinlets are quite irregular in form, and both crosscut and follow the cleavage and schistosity. Also included within the ore bodies are streaks and veins of massive chalcopyrite and pyrite, some as much as 2 feet wide. An envelope of coarse-grained pyrite surrounds the ore bodies in most places, and grades outward into country rock containing more sparsely disseminated pyrite. The tapering ends of these pyritic envelopes extend some distance beyond the ore bodies and have been useful guides to their location.

The chalcopyrite and pyrite are closely associated and, in many places, intimately intergrown. The two sulphides are apparently of the same age, in the sense that they were introduced together, though pyrite may be seen which is penetrated and cut by veinlets of chalcopyrite. Bornite is rare, but in a few places was observed as scattered small grains intergrown with the other sulphides. Locally ilmenite is present as splendent flakes, and Reid [14] has noted that it is more abundant toward the borders of the sulphide lenses. Knopf [15] reports the presence of sphene

[14] Reid, J. A., The ore deposits of Copperopolis, California: Econ. Geology, vol. 2, pp. 399-400, 1907.

[15] Knopf, A., Notes on the Foothill copper belt of the Sierra Nevada: Univ. California, Dept. Geol. Sci. Bull., vol. 4, pp. 411-423, 1906.

(titanite) and rutile, as well as a few crystals of andalusite, in the "ore rock" of the Copperopolis mines.

Other than those in the chloritized rock, gangue minerals are not abundant. White quartz and calcite are present as small lenses and veinlets. Epidote as large crystals or as small radiating groups was seen in occasional vugs in the ore. In small amounts, hematite and hematitic jasper occur within the wall rock adjacent to the ore bodies. Knopf[16] also reports chalcedony from the Copperopolis mines.

No supergene copper minerals were observed by the writer within the North Keystone mine. In the gossans in the vicinity of the mine thin seams of malachite and occasional specks of cuprite and azurite are present. The bulk of these gossans are made up of iron oxides and quartz.

In the mine the three main ore bodies are designated, respectively, the North, Middle, and South (pl. 37). In plan they are en echelon, each lying east of its northern neighbor. They are parallel to those segments of the Footwall fault having a more northerly strike; it is noteworthy that where the fault locally bends more to the west, the ore bodies do not show a corresponding change in strike. The larger ore bodies are developed adjacent to those segments of the Footwall fault having the more northerly strikes, as is particularly well shown by the relations on the 675 level. Where intersected by subsidiary faults or bifurcations of the Footwall fault, the ore bodies show little or no offset.

During the recent operation of the mine (1942-45) all three of these bodies were mined, as well as any smaller pods or streaks of ore of sufficient tenor. The grade of ore in the mine varies between $1\frac{1}{2}$ and 9 percent copper, with scarcely any gold or silver content, and the monthly averages of tenor of ore mined during the years 1942-45 ranged from $1\frac{3}{4}$ to 4 percent copper.

The top of the North ore body is a short distance above the 525 level. This body lies against the Footwall fault, and extends downward through all the lower levels of the mine. It has a maximum width of 20 feet, and strike length of 360 feet. On the 1075 level it is much reduced in size, apparently the result of the presence of a 9-foot sill of granodiorite, which, though sheared and cataclastically deformed, was not especially favorable to replacement by the ore-bearing solutions.

The Middle ore body is composite, its upper 400 feet consisting of two parallel lenses separated by a narrow width of strongly pyritized slate. Its top is 75 feet above the 375 level, and it extends downward from there about 525 feet. It is absent on the 875 level, where it is represented by a zone of heavily pyritized slate and granodiorite. Below this, on the downward projection of its trend, a lens of ore is present, and is well developed on the 1075 level, where it is $7\frac{1}{2}$ feet wide. The Middle ore body has a maximum width of 20 feet, and strike length of 240 feet.

The South ore body consistently produced ore of slightly higher copper content than the other two major bodies. In it replacement of chloritized rock by sulphides is more complete, and consequently less interstitial rock is present in the ore. This ore body extends downward from 100 feet above the 525 level of the mine. It has a maximum width of 15 feet, and strike length of 285 feet. On the bottom level (1075) it is well developed, forming the largest mass as well as the best grade of ore at that depth.

[16] Knopf, A., idem.

Because the intense chloritization characteristic of the mineralized zone is absent for 1,675 feet along the trace of the Footwall fault between the North Keystone and Keystone-Union mines, the possibility that bodies of ore are present in this segment seems remote. Northwest of the North Keystone mine, however, the outlook is more favorable, for there the belt of chloritization is strongly developed, and several areas of gossan are evident. During 1943 the U. S. Bureau of Mines carried on exploratory diamond drilling along the downward projections of some of these gossans. Four holes, totaling more than 2,600 feet were drilled in this area. According to the Bureau of Mines [17] reserves located were 11,000 tons of commercial ore containing 3.0 percent copper in a zone 3.0 feet thick, and 5,000 tons of submarginal ore containing 0.7 percent copper in a zone 2.6 feet thick. This drilling program also indicated the presence of several thin chalcopyrite-pyrite stringers in the rocks west of the Footwall fault, their chief locus being in the green schist, close to or at its contact with the slates west of it.

In summary, the important ore controls recognized at the North Keystone mine may be itemized as follows:

1) Ore bodies of commercial size and tenor are restricted to a belt of intense chloritization.

2) The chloritized slate and schist within this zone of alteration afforded the most favorable environment for penetration and replacement by the copper-bearing solutions. Granodiorite, even where sheared, crushed, and thoroughly chloritized, has been less conducive to replacement; therefore, where granodiorite occupies a proportionally large width in the belt of chloritization, the copper deposits, if present, are generally lean, and in many places give way to heavy streaks of pyrite or virtually barren rock.

3) A prominent fault—known as the Footwall fault from its relation to the chloritized zone containing the ore bodies—and subsidiary faults and fissures in its hanging wall served as ground preparation for the ingress of hydrothermal solutions that brought about the alteration and replacement of some of this rock by chalcopyrite and pyrite.

4) The Footwall fault, in detail, shows minor changes in strike, alternating through as much as 15° from a more northerly to a more westerly course, and back again. The larger ore bodies are parallel to those segments having the more northerly strike; where the fault deviates from this, the adjacent ore bodies show no corresponding change in their strike.

Keystone-Union Mine

The Keystone-Union mine is the largest in the Copperopolis district, and includes all the underground workings tributary to the six shafts known, from north to south, as the Keystone-Discovery, Keystone, Union No. 1, Union No. 2, Union No. 3, and South Union. These workings are developed along a 2,000-foot length of the mineralized zone, with the deepest level of the mine, known as "1,800", approximately 1,350 feet vertically below the surface. Its two main shafts, the Keystone-Discovery and Union No. 1, are steeply inclined toward the east, more or less following the dip of the mineralized zone. They were originally the means of access to separate mines that merged in the course of their development.

[17] North Keystone mine, Calaveras County, California: U. S. Bur. Mines War Minerals Rept. 342, pp. 1-8, 1944.

The mine has been inactive since 1930, and the underground workings were not accessible for examination by the writer. Consequently, conclusions regarding this mine are based on the study of the surface geology (pl. 35), and on information obtained from available maps and assay records (pls. 38 and 39).

The slates and metavolcanic schists forming the country rock at the Keystone-Union mine are similar to those on their northwest strike continuation at the North Keystone mine. They include dark blue-gray argillaceous slate, green schist and greenstone derived from volcanic rocks of intermediate composition, bedded tuff, hornstone, and volcanic breccia. Most of these have a well-developed schistosity or cleavage which dips steeply eastward.

About 200 feet west of the mine is a moderately large granodiorite intrusion, lenticular in form, almost 2,000 feet long, and up to 240 feet wide. East of this, and in part contiguous with it, is an elongate body of dark-green serpentine, 1,730 feet from end to end, with a maximum width of 85 feet. Both these intrusive masses trend northwest, parallel to the regional strike of the enclosing metavolcanic rocks. Smaller bodies of granodiorite, quartz diorite, and hornblendite are also present in the area east and southeast of the serpentine. In the underground workings of the mine, as mapped by McPherson (pl. 38), a narrow dike of hornblendite is shown, as well as larger masses of granodiorite and serpentine.

The greater portion of the eastern boundary of the elongate serpentine mass is an east-dipping fault which, when traced northwest, is found to be continuous with the Footwall fault at the North Keystone mine. In the Keystone-Union mine area it is marked by a well-developed zone of gouge, which along much of its course is talcose and contains finely disseminated magnetite. The displacement on this fault decreases southward, and it apparently dies out a short distance southeast of the mine. Near the Stockton road its strike slip, as expressed by offset of the quartz diorite intrusion, is of the order of 100 feet, and farther southward evidence of displacement is lost. It is possible that the fault branches a short distance north of the quartz diorite intrusion, with a west fork following the border of the serpentine mass marked by a wide zone of talc schist (pl. 35).

A zone of intense chloritization, similar in all respects to that at the North Keystone mine, lies adjacent to this fault, and contains the ore bodies. It begins on the north as two narrow prongs of altered rock near the Keystone-Discovery shaft; these merge southward into a wider belt of alteration, which near the South Union shaft reaches a width of more than 200 feet.

Dump material indicates that the ore bodies are made up of anastomosing veinlets and irregular streaks and masses of chalcopyrite and pyrite; other metallic minerals, such as bornite and ilmenite, were not observed, but may be present in small amounts as at the North Keystone mine. The ore bodies are distributed in the chloritized zone as lenticular masses more or less parallel to the foliation. In plan they seem to have no systematic arrangement (pl. 38), though Reid [18] states ". . . the ore occurs as a series of overlapping lenses, often arranged *en echelon* . . ." The vertical projection of the mine and its ore distribution (pl. 39), constructed from assay data, indicates the ore shoots, in general, have a

[18] Reid, J. A., op. cit., p. 408.

steep north rake. Their boundaries are vague, one ore shoot grading into another through a lean zone. The assay data show that in width these lenses range up to 33 feet; in pitch length they reach 600 feet to possibly twice that figure, and in strike length 350 feet or more. The tenor of the ore ranges from less than 1 percent to 18 percent copper, with much of it running higher than 2 percent copper.

The footwall of the mineralized zone throughout most of the mine is serpentine and talc; the hanging wall, in part, is argillaceous slate, and, in part, metavolcanic schists and granodiorite. The distribution of material on the mine dumps suggests that vein quartz becomes more abundant toward the south end of the mine. Some quartz veinlets crosscut the ore minerals, which would indicate that this quartz was introduced at a late stage in the mineralization sequence.

Empire Claim

Southeast of the Keystone-Union mine is the Empire claim, on which is the inactive Empire mine with no reported production since 1867. It consists of a vertical shaft, said to be more than 300 feet deep, and several levels of unknown extent. Near the shaft and toward the south end of the claim are many smaller openings—shafts, pits, and adits—the most important of which is the Empire tunnel. This was the only opening on the claim accessible for extensive examination.

Southeast of the Keystone-Union mine the zone of intense chloritization continues without interruption, and near the Empire shaft reaches its greatest width, approximately 300 feet. The chloritization has affected schists derived from volcanic rocks of intermediate composition, along with several smaller bodies of granodiorite and hornblendite intrusive into them. Veins and veinlets of white quartz, in some places carrying small amounts of calcite and feldspar, are more numerous in this portion of the alteration belt than elsewhere; their presence gives the rock greater resistance to erosion, causing it to stand up as a low ridge. Disseminated pyrite is widespread. Narrow streaks and pockets of iron oxides, in places associated with small amounts of malachite and cuprite, are not uncommon in this vicinity. Browne [19] reports dendritic native copper to be present in the outcrop of the ore-bearing zone on the Empire claim. According to Reid [20] much siliceous copper ore has been taken from the Empire shaft.

About 150 feet southwest of the Empire shaft collar is an elongate serpentine body whose eastern boundary is a prominent fault line marked by talcose gouge. This is the Calaveras fault, a high-angle, east-dipping fault that can be traced along its strike for more than 2,000 feet. It is analogous in many respects to the Footwall fault of the central and northern part of the district, for here the zone of chloritization, in a general way, has followed it, and the copper mineralization is most strongly developed along this fault or in its hanging wall.

The Empire tunnel is an adit about 420 feet long driven through the mineralized zone near the south end of the Empire claim. It has been mapped in detail (pl. 40), and sampled for ore.

[19] Browne, J. R., Mineral resources of the States and Territories west of the Rocky Mountains for 1866, p. 146, 1867.
[20] Reid, J. A., op. cit., p. 410.

The adit penetrates greatly disturbed metavolocanic rocks—chiefly schistose pyroclastics and spotted green schists—with foliation in most places dipping steeply eastward. Into them are intruded dikes and irregular bodies of gabbro, hornblendite, hornblende diorite, and granodiorite, the latter being affected by the chloritization and sulphide mineralization, as at the North Keystone mine. Along a narrow zone in hornblendite, about 175 feet from the tunnel entrance, disseminated pyrite with scattered grains of chalcopyrite is present. The strongest mineralization is adjacent to faults or shear zones in chloritized schist west of the granodiorite body in the central part of the tunnel. The Calaveras fault is represented by a shear zone about 5 feet wide in which the most prominent fault surface dips 59° eastward. The hanging wall is chloritized and contains stringers of pyrite, chalcopyrite, and quartz veins, and disseminated pyrite is present in the zone itself. Contrary to the report by Reid,[21] no large quantity of copper ore was observed in the walls of this adit; representative samples of the mineralized zones in all cases assayed less than 1 percent copper.

McCarty Prospect

The McCarty prospect is on the Calaveras claim, immediately south of the Empire claim. It consists of two shallow shafts, the southern one 35 feet deep, the northern one partially caved and of undetermined depth. Extending northwest from the southern shaft are two short levels connected by an irregular open stope, near the north end of which is a winze that extends below water level.

The accessible workings are within the oxidized zone, the base of which, at the McCarty prospect, is approximately at 50 feet depth, the position of the water table. The mineralization follows a 2- to 7-foot zone of crushing and shearing along the southwest side of a high-angle fault; this, the McCarty fault, strikes parallel to the related Calaveras fault which is 20 to 25 feet to the east. At the surface the McCarty fault dips east. In the underground workings, however, the fault swings through vertical and has a steep westward dip. It is possible that this reversal of dip has served as a locus of mineralization here.

The ore consists of a mixture of malachite and cuprite in limonite, with small amounts of azurite and, in the lower portion of the workings, chalcopyrite. Encrustations of chalcanthite are not uncommon. This oxidized material is derived from a mixture of chalcopyrite and pyrite, small residual masses of which are present below 20 feet depth. No gangue minerals were observed, other than small veinlets of white quartz.

The wall rocks are green spotted chlorite schist derived from volcanic rocks of intermediate composition. Within the zone of copper mineralization are thin streaks of intensely chloritized rock, similar in character to the chloritized schist present at the North Keystone and Keystone-Union mines. The chloritization is restricted to a width of 3 to 4 feet adjacent to the McCarty fault.

POTENTIALITIES OF THE DISTRICT

The Copperopolis district is one of the most favorable areas in the Foothill copper-zinc belt for the finding of additional copper reserves. Because of the wide extent of the alteration zones, and the continuation

[21] Reid, J. A., op. cit., pp. 410-411.

of the mineralization with depth, the district offers better than average opportunities for the discovery of ore.

The most obvious locations for untouched reserves are, of course, the downward extensions of known ore shoots in both the North Keystone and Keystone-Union mines. Economic factors, however, will determine whether or not ore can be recovered at a profit.

Several of the ore bodies in the mines do not crop out, and the likelihood is strong that additional blind shoots are present in the district. Exploration for these should be restricted to the belts of strong chloritization, and particularly to ground adjacent to faults or close to the intersection of faults. Where surface exposures are poor and underground examination impractical, geophysical methods, such as dip-needle or magnetometer surveys, will probably be of considerable aid in the delineation of significant faults. Special attention should be devoted to areas in which pyritization is strong, for the known ore bodies are generally surrounded by an envelope of disseminated pyrite. The ground immediately north of the North Keystone mine, and that at the south end of the Keystone-Union mine, in light of present knowledge, are two areas that should warrant the most thorough prospecting.

THE ZINC-COPPER MINES OF THE QUAIL HILL AREA, CALAVERAS COUNTY, CALIFORNIA *

By George R. Heyl **

OUTLINE OF REPORT

ILLUSTRATIONS

INTRODUCTION

The mines described in this chapter are in the foothills of the Sierra Nevada, near their western edge, 6 to 6½ miles southwest of Copperopolis (pl. 1). The Quail Hill and Collier mines, near the north and south ends, respectively, of a 5-mile belt of zinc-copper mines and prospects, were active during World War II. In addition to these mines, the more important mines and prospects are the Napoleon mine and the Gopher Hill, Star-Excelsior, and Little Quail Hill prospects.

The Napoleon mine is the oldest copper mine in the Foothill belt, copper having been discovered in the gossan of this deposit soon after the discovery of gold in the Quail Hill gossan in 1861.

The deposits occur in metavolcanic rocks of probable Jurassic age, at or near the contact of felsite or quartz porphyry intrusions into these volcanics.

The ore shoots are pod-shaped and lenticular masses. At the Quail Hill mine they were formed by the replacement of felsite and felsite breccia along faults and shear zones adjacent to the contact of the intrusive body, and particularly at salients or local irregularities on this contact. The Gopher Hill mine has a somewhat analogous location along the edge

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of a felsite intrusion. The Napoleon mine occurs in a shear zone in quartz porphyry and felsite near the contact with the volcanics. The Collier mine is likewise along a fault zone which follows, or is close to, a similar contact between volcanics and intrusive rocks.

The ore from these mines is principally an intimate mixture of sphalerite, chalcopyrite, and pyrite, but contains gold and silver and small amounts of galena. The extension of the mineralized zone with depth at the Quail Hill mine gives promise of locating additional ore bodies at the mine.

The Quail Hill mine and surroundings were mapped in detail by the U. S. Geological Survey. A detailed surface map of the Napoleon mine area was also made. Only brief studies were made of the accessible underground workings of the Gopher Hill, Napoleon, and Collier mines. The Star-Excelsior and Little Quail Hill mines were visited briefly.

QUAIL HILL ZINC-COPPER MINE

Introduction

The Quail Hill zinc-copper mine lies in sec. 3, T. 1 N., R. 11 E., Calaveras County, California, approximately 6½ miles southwest of the village of Copperopolis (pl. 1). It is located near the northern end of a 5-mile belt of copper-zinc mines and prospects that are developed in volcanic rocks, and in quartz porphyry and felsite intrusions.

During parts of 1943 and 1944, the mine and the area immediately adjacent to it were mapped by G. R. Heyl, J. B. Hadley, C. M. Gilbert, and M. W. Cox of the U. S. Geological Survey, as part of a wartime study of the Foothill copper-zinc belt.[1]

The mine is on patented ground designated in the Calaveras County records as the Eagle claim. The property is owned by G. Ivan Smith of Bell, California, and the mine was operated by him from September 1942, to November 1944. During the greater part of this period the late R. L. Kirk of Copperopolis served as superintendent. In 1945 the mine was operated for a short time by "leasers."

The mine consists of a two-compartment vertical shaft 280 feet deep, with levels at 70, 170, 205, and 270 feet, and sublevels at 190 and 296 feet. In addition, there is an adit close to the shaft collar, which formerly connected with a glory-hole opened on the mineralized outcrop. Mining was carried on in open stopes, which later were generally filled or allowed to cave. During the recent study, considerable portions of the upper part of the mine were inaccessible because of caving.

The property is in hilly country, in a region of mild winters and hot, dry summers. It is accessible by an all-weather road extending 2 miles south from the mine to the ranch known as Telegraph City on State Highway No. 4. This highway leads to a branch of the Southern Pacific Railroad at Farmington, about 14 miles west of Telegraph City.

It is a pleasure to acknowledge the able assistance of C. M. Gilbert, J. B. Hadley, and M. W. Cox, members of the U. S. Geological Survey, who materially contributed to the field work involved in this study. Mr. Gilbert also aided the writer in the preparation of part of the manuscript. D. G. Wyant of the U. S. Geological Survey assisted the writer in logging some of the diamond-drill core.

[1] Strategic Minerals Investigations, Preliminary Maps 3-182, Quail Hill mine, Calaveras County, Calif., 1945.

The late Mr. Roy L. Kirk of Copperopolis, California, kindly furnished several old maps and sections of the mine, as well as much other valuable information used in this report. The owner of the mine, Mr. G. Ivan Smith of Bell, California, generously allowed us to study the property and to publish our observations. Mr. P. R. Bradley, Jr., has granted us permission to include assay data from the files of the Pacific Mining Company. Mr. Francis Frederick very kindly supplied data on the 296-foot sublevel of the mine.

Information relating to the production of the mine was made available to the author by C. W. Merrill of the U. S. Bureau of Mines. Sincere thanks are due to R. S. Cannon, Jr., of the U. S. Geological Survey, and to Olaf P. Jenkins of the State Division of Mines for their helpful criticism and advice relating to the preparation and publication of this paper.

History and Production

The Quail Hill mine was the first mine located in the Foothill belt. In November 1860, Hiram Hughes, a local resident who had recently returned from the Comstock Lode, discovered the gossan at Quail Hill, and began working it for gold. Soon afterwards, he also noticed the outcrop of the ore body at what was later the Napoleon mine, 2½ miles to the southeast of the Quail Hill mine. Finding less gold at the Napoleon mine, he sent some of the ore to San Francisco, where it assayed 30 percent copper. Local excitement broke out, and thus began California's important copper boom of the sixties.[2]

The presence of copper ore at Quail Hill was apparently soon discovered, for between 1863 and 1869 several hundred tons of copper ore were shipped from the Napoleon and Quail Hill mines, the latter yielding large quantities of carbonates and oxides of copper, along with considerable gold and silver.[3]

After this period of early activity, the mine has no known record of production until 1917, when the Quail Hill Mining Company of Milton operated the property and mined ore for 3 years, chiefly from the 170-foot level and above. In 1920 the mine was taken over by W. H. Hamilton of San Francisco, but from 1921 to 1937 it was again idle. In 1938 there was a brief period of activity under the management of the Bullion Gold & Silver Mining Company of Milton, when a small amount of copper and precious metals was produced. The recent period of production of ore began in March 1943, and continued until late in 1944. After an interval of idleness, production was renewed during part of 1945.

No record of the amount of ore produced from this mine during its early period of activity is known. The known production of the mine since 1888 is given in table 1.

General Geology

The Quail Hill mine is located close to the western edge of the Sierra Nevada foothills, within 2½ miles of where the metamorphic rocks of the range are overlapped by the Tertiary sediments of the San Joaquin Valley. These lower foothills are made up of a thick sequence

[2] Browne, J. R., Mineral resources of the States and Territories west of the Rocky Mountains for 1866, pp. 138-169, 1867.

[3] Aubury, L. E., The copper resources of California: California Min. Bur. Bull. 50, pp. 31-33, 1908.

Table 1. Known production of the Quail Hill mine

Period	Ore (short tons)	Copper (pounds)	Zinc (pounds)	Lead (pounds)	Gold (fine ounces)	Silver (fine ounces)
1888-1916	*	*	*	*	*	*
1917	2,075	220,022	------------	------------	747	11,698
1918	942	109,087	------------	------------	169	7,072
1919	500	21,600	------------	------------	68	1,080
1920	583	70,405	------------	------------	259	3,624
1921-1937	*	*	*	*	*	*
1938	400	3,525	------------	------------	16	133
1939-1942	*	*	*	*	*	*
1943	3,609	[1]317,609	[1]1,480,820	[1]75,977	1,845	25,114
1944	4,337	[1]159,164	[1]581,251	[1]71,975	742	16,624
1945	241	[2]4,000	[2]2,000	------------	20	121
Totals	12,687	905,412	2,064,071	147,952	3,866	65,466

* No production reported.

Source of information: San Francisco office, Metal Economics Branch, U. S. Bureau of Mines, 1917-44; Minerals Yearbook, U. S. Bureau of Mines, 1945.

[1] Pounds of metal contained in concentrates.

[2] Pounds of recovered metal.

of lavas and pyroclastics, and a variety of intrusive rocks. Both types of igneous rocks are in part metamorphosed to low-rank schists and greenstones. The volcanics usually dip steeply to the northeast, and have a fairly constant northwestward regional strike. The schistosity, where developed, is in general parallel to this regional strike and dip.

Field evidence indicates that the stratigraphic section in the immediate vicinity of the Quail Hill mine is in normal sequence and not overturned, though elsewhere in the Foothill belt there are folds of considerable magnitude, along with overturning of beds. The volcanic rocks are very probably a portion of the Amador group which has been dated by Taliaferro [4] as Upper and possibly Middle Jurassic.

Volcanic Rocks. Within the area included on the map (pl. 41), three main units of volcanic rocks tentatively assigned to the Amador group are distinguished—(1) dacite and andesite, (2) basalt, and (3) tuff. The westernmost of these units (1), and the oldest, consists of medium to light-gray and gray-green aphanitic,[5] and in part porphyritic, lavas. The visible phenocrysts are plagioclase, in places accompanied by quartz, so that these rocks are given the field classification of dacite and andesite. These rocks are, in general, quite massive, with little evidence of flow structures, but their extreme fineness of grain and an occasional intercalation of tuff suggest that they are lavas.

To the east, overlying this unit, are dark-gray and dark-green lavas and volcanic breccias (2). They are distinguished from rocks of the other units by their very dark color, which, together with their well-developed plagioclase phenocrysts, suggests basaltic composition. Some of the lavas are amygdaloidal, the amygdules most commonly being white quartz, though some of quartz and feldspar and others of quartz and calcite were also observed.

The breccias of this unit range in texture from coarse to fine, and consist entirely of volcanic material, much of it similar to the associated

[4] Taliaferro, N. L., Geologic history and correlation of the Jurassic of southwestern Oregon and California: Geol. Soc. America Bull., vol. 53, p. 90, 1942.

[5] An aphanitic rock is one in which the constituent grains cannot be distinguished by the unaided eye.

basaltic flows. However, the matrix is generally paler-green tuffaceous material, pointing to a pyroclastic origin for the rock.

Within the basalt unit, and exposed at the mine, is a lentil of thin-bedded commonly laminated, pale-gray and greenish-gray fine-grained tuffs. Included with them are several thicker layers of pyroclastic breccia.

To the east of the basalt unit is a sequence of fine-grained pale-gray tuffs (3) that are generally well-bedded. Their water-laid origin is suggested by several observed irregularities and discontinuities in the bedding, perhaps due to slumping at the time of deposition, and by grain gradation within beds. Intercalated with these bedded tuffs are massive members, some of which are diabase and possibly intrusive, while others are aphanitic and probably dacitic flows.

Intrusive Rocks. The largest intrusion at Quail Hill is an irregularly shaped felsite body, about 1,900 feet long and 1,500 feet wide, extending northwestward from the mine to beyond the limits of the areal map. It is a uniformly aphanitic, nonporphyritic, pale-gray rock warranting the field designation of felsite. The body as a whole cuts across the volcanic rocks, and in detail small offshoots of felsite extend out into them. The felsite has been altered—sericitized and kaolinized, and locally silicified and pyritized. In the vicinity of the mine the rock is commonly schistose, its schistosity in general being parallel to the regional attitude of the foliation of the volcanic rocks, and in many places at marked angles to the contact of the intrusion.

Closely associated with the felsite is a medium-gray massive rock, with small feldspar and quartz phenocrysts embedded in an aphanitic groundmass. It is designated felsite porphyry. Except along fracture surfaces this rock shows little effect of alteration. Because of the close spatial relationship, it most probably is a porphyritic facies of the felsite; however, it might have been intruded separately.

Numerous small bodies of quartz porphyry, nearly all of which are breccia, occur in the bedded tuff unit, to the east of the mine. They consist of large and small blocks and fragments of lighter-gray quartz porphyry embedded in a somewhat darker quartz porphyry. In some cases phenocrysts of feldspar as well as of quartz are present. The intrusive character of some of these bodies is clear from their cross-cutting relationships to the bedded tuffs.

Dikes of gray and dark greenish-gray diabase and diabase porphyry cut the felsite intrusion and the volcanic rocks. In the vicinity of the mine these dikes are generally kaolinized, some being so completely altered as to be simply white clay. Though they cut the schistose felsite, there is no foliation developed in them.

Structure

Where bedding or flow-structure is discernible in the volcanic rocks, the strike is, fairly consistently, northwest with a northeast dip at angles generally between 50° and 70°. A noteworthy exception to this homoclinal structure is the pair of southward plunging, small folds in the southeastern part of the map-area; these folds are apparently limited in their extent along the strike.

In most places bedding dips eastward less steeply than regional schistosity or cleavage. This relationship, together with a consistent grain gradation within beds, is indicative that the base of the series is to the west, and that the local section is right side up.

The contact of the felsite intrusion along its southeastern portion is well exposed on the surface and in the mine. In this area it dips steeply eastward, and shows local irregularities in both strike and dip. In general, it is crosscutting and disconformable, but at the major salient of the contact exposed in the mine the bulge is partly reflected in the country rock by a flexure in the immediately adjacent tuffs. Shearing and brecciation have been considerable along this contact, and faulting and crushing have been more extreme in the vicinity of the salients and local irregularities of this surface. This evidence of tectonic movement along the intrusive contact suggests that the felsite was emplaced before the regional orogeny. Because of the extremely fine grain of the felsite, it is probable that the body was emplaced at shallow depth before a thick cover of overlying rocks had accumulated above it.

The dikes of diabase and diabase porphyry are nonschistose, whereas the felsite which they cut shows a well-developed schistosity parallel to that present in the surrounding country rock. This fact may mean that the dikes were intruded after the regional orogeny.

Ore Bodies

The ore shoots at the Quail Hill mine are pod-shaped and lenticular masses, formed by the replacement of felsite and felsite breccia along faults and shear zones adjacent to the contact of the intrusive body, and particularly at salients or local irregularities on this contact. The felsite in the vicinity of the ore bodies is pyritized, the intensity of the pyritization in a general way increasing as the boundaries of the ore are approached.

The hydrothermal solutions that brought in the sulphides, as well as those that caused the alteration of the rocks adjacent to the ore shoots, probably followed as channelways the zone of crushing and shearing along the felsite contact and fault and fracture zones related to irregularities on the contact. There is also a suggestion, as brought out by the mine sections of plate 44, that the dikes of diabase and diabase porphyry may have served as dams which partly inhibited the circulation of these solutions.

The largest ore shoot is best exposed on the 205-foot level (pl. 42), and in the sublevel above it. Above the 170-foot level this ore body was mined during World War I, and its shape and extent are inferred from the character of the old mine workings, and from the assay maps and sections available. They indicate that it extended 70 to 75 feet above the 170-foot level, where it apparently pinched out in an inverted keel, trending possibly 20° east of north. The ore shoot widens downward, and below the 170-foot level it becomes more equidimensional in horizontal cross-section, thence tapering as a funnel-shaped body and pinching out at a depth of approximately 240 feet. The ore shoot as a whole parallels the adjacent hanging wall of the felsite intrusion, which lies a few feet to the eastward; the shoot has an easterly dip with an average plunge[6] of approximately 68° to the southeast. The extreme upper and lower ends of this ore shoot do not show on section A-A′ (pl. 44), because

[6] Plunge, as here used, is defined as the vertical angle between a horizontal plane and the line of maximum elongation.

the southeast plunge throws them out of the plane of the section. The total pitch length is approximately 177 feet.

High-grade ore made up the entire shoot. Smelter returns show that 2,622 tons shipped to Tacoma, Washington, during World War I averaged as follows: 5.58 percent copper; 15.60 percent zinc; 0.40 ounces of gold to the ton; and 6.51 ounces of silver to the ton. Much of the ore mined from this body during the recent operation was of similar grade; the lead content ranges between 0.5 and 1.8 percent.

Several interesting variations in grade within this body have been discovered by mining. Between 211 and 191 feet depth the ore showed a prominent flat platy parting; within this vertical range the gold tenor was unusually high, the smelter returns showning an average of 1.25 ounces to the ton, and the copper tenor was somewhat lower than normal. Above 191 feet the platy parting was not evident in the ore, and the gold content was close to average. However, between 190 and 170 feet the zinc content increased appreciably, the ore there averaging 30 percent zinc. A marked local increase in tenor occurred just below the floor of the 170-foot level, where on the northeast side of the ore body an abrupt tonguelike extension of ore projected several feet eastward. The ore lying on the more or less flat floor of this salient was of unusually high grade, one mine-car sample assaying 13.00 percent copper, 5.14 ounces of gold to the ton, and 11.26 ounces of silver to the ton. Such variations in metal content illustrate the significance of the detailed configuration of the walls in relation to ore tenor.

This ore shoot, and also some of the smaller ones in the mine, are bounded by fault surfaces in several places. Faults also penetrate the ore. However, there is no displacement of the sulphide bodies by these faults, and in some cases small veinlets of sulphides have been deposited within the gouge. This is considered strong evidence supporting the view that the ore was introduced after the development of the faults, and that these faults served as important loci of mineralization, and probably, in some cases, as channelways.

The smaller ore bodies in the mine are similar in their mode of occurrence, being likewise spatially related to salients in the hanging wall of the felsite intrusion, or to faults, or a combination of both.

In section A-A′ (pl. 44) an old stope is shown above the 70-foot level. Though this stope is not accessible, its position and that of the hanging wall of the felsite in its vicinity have been plotted from data obtained from old maps and sections, and from drill-hole information. Its position suggests that the ore body in which the stope was developed was also related to a salient in the hanging-wall contact of the felsite.

The ore of the Quail Hill mine is principally an intimate mixture of sphalerite, chalcopyrite, and pyrite, but contains gold and silver, and small amounts of galena. Barite, the chief gangue mineral, generally is present sparsely with the sulphides, but locally may form an appreciable portion of the ore; where barite is abundant it is designated as baritic ore. Other gangue minerals observed are quartz, calcite, and powdery green chlorite.

Wall-Rock Alteration. Pyritization is widespread at Quail Hill, several zones being apparent on the surface to the south and west of the mine. The main zone of pyritization, however, is developed in a broad belt of felsite adjacent to its eastern contact in the vicinity of the mine. Most commonly in this zone the pyrite is finely disseminated through the

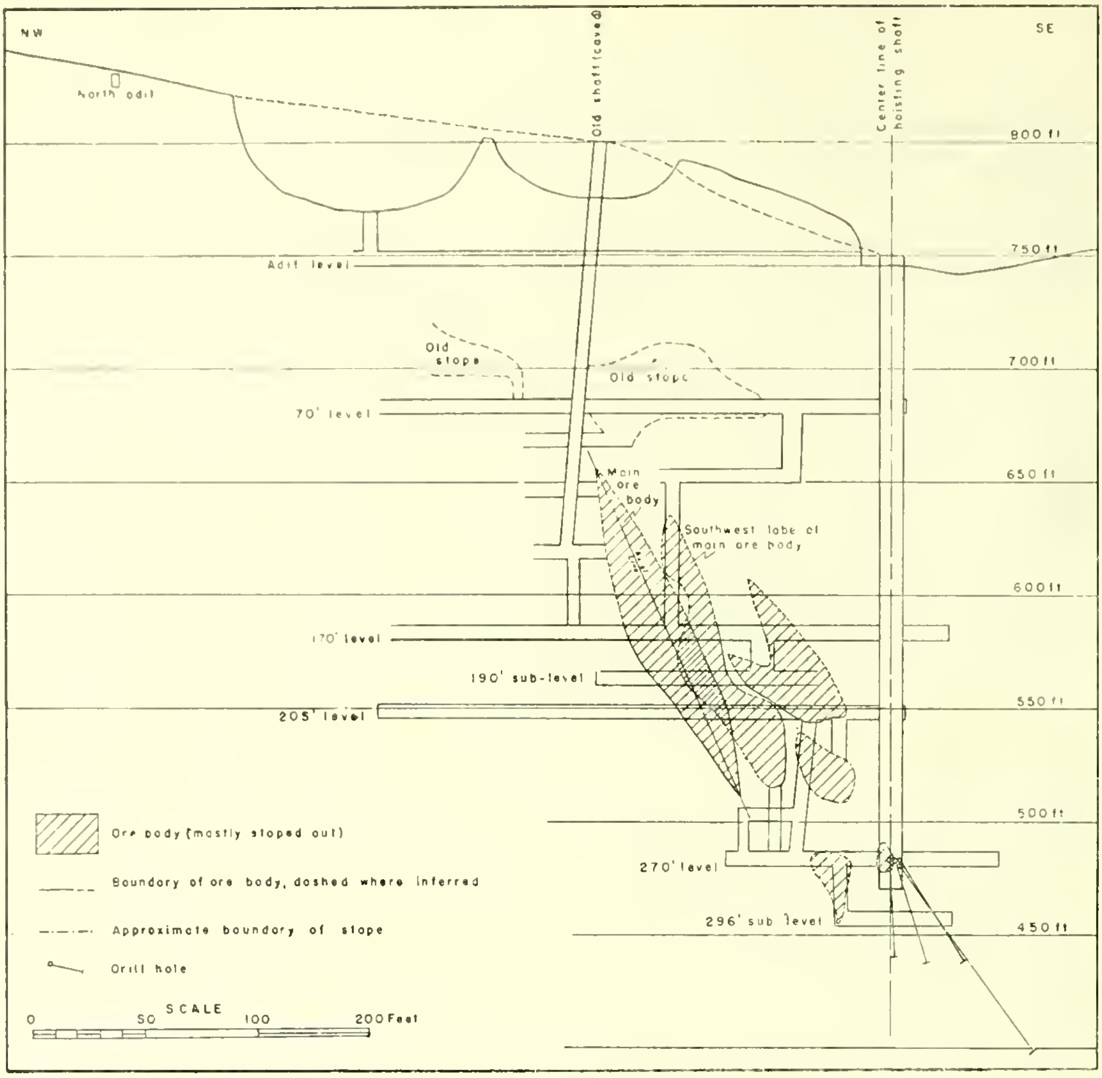

Fig. 1. Vertical projection on a plane N. 37° W., Quail Hill mine, Calaveras County, California. Compiled November 1944 from old records and recent mapping by the Geological Survey.

rock in moderate amount, but in local streaks the pyritization is intense, in some places almost completely replacing the rock. Pyrite seems to be more abundant in the breccia zones of the felsite, and in a general way the areas surrounding the ore bodies are more intensely pyritized. In places a certain amount of pyrite has been introduced into the diabase dikes and the tuffs of the hanging wall, but in neither of these rocks is the pyritization as widespread or as intense as in the felsite. Much of the pyrite is auriferous, enough so in some cases to make the rock gold ore.

Where the light-colored, bedded tuffs form the hanging wall in the mine, a few inches to a foot of the tuffs immediately adjacent to the felsite are commonly impregnated with finely disseminated magnetite. This rock is dark in color and deflects the compass. Magnetite was not observed elsewhere along this contact, or in the ore.

The types of rock alteration present at Quail Hill include kaolinization, sericitization, and silicification in addition to the pyritization described above. Kaolinization has been the most widespread type of alteration and affects the felsite, the diabase dikes, and, to a less extent, the hanging-wall tuffs. In many places it has been very intense, altering the rock to a white clay of undetermined composition. This intense kaolinization has especially affected the diabase dikes in the proximity of the ore bodies, but it has affected also certain zones in the felsite. Sericitization is less evident, but has also affected the felsite, and is apparently more intense in the more strongly pyritized rock. Silicification seems to be limited to local areas in the felsite. More detailed information concerning the rock alteration must await microscopic studies.

Supergene Ore Zone. Because the upper workings of the mine are largely inaccessible, little direct information was obtained during the recent study concerning the zone of secondary enrichment. In 1867 the mine was visited by Silliman,[7] who published a brief account of his impressions. At that time the gossan and oxidized zone were apparently being worked, for Silliman says: "Accompanying the entire mass of decomposition at [Quail Hill] occur both gold and silver, disseminated with remarkable uniformity in all parts of the ore-bearing ground . . . . But it is rare that, on washing a small quantity of any of the contents of these great deposits, gold is not found in angular grains or small ragged masses, from the size of a few grains' weight, to impalpable dust. Nuggets of several pennyweights occur occasionally. This gold has evidently accompanied the sulphurets and been left in its present position and condition by their decomposition."

Silliman mentions the presence of copper glance at Quail Hill, but gives no figures as to the depth of workings or the position of occurrence of the mineral. He also observed the occurrence of copper carbonates, chrysocolla, cuprite, native copper, sphalerite, and galena, but not chalcopyrite. This occurrence suggests that at that time mining had not penetrated below the oxidized zone. He reports that the mean of his assays "on the average mass of vein stuff and decomposed materials of every name at Quail Hill" gave to the ton of 2000 pounds the following values:

Gold $35.14
Silver $15.08

[7] Silliman, Benjamin, Jr., Notice of a peculiar mode of occurrence of gold and silver in the foothills of the Sierra Nevada, and especially at Whiskey Hill, in Placer County, and at Quail Hill in Calaveras County: Am. Jour. Sci., 2d ser., vol. 45, pp. 92-95, 1868.

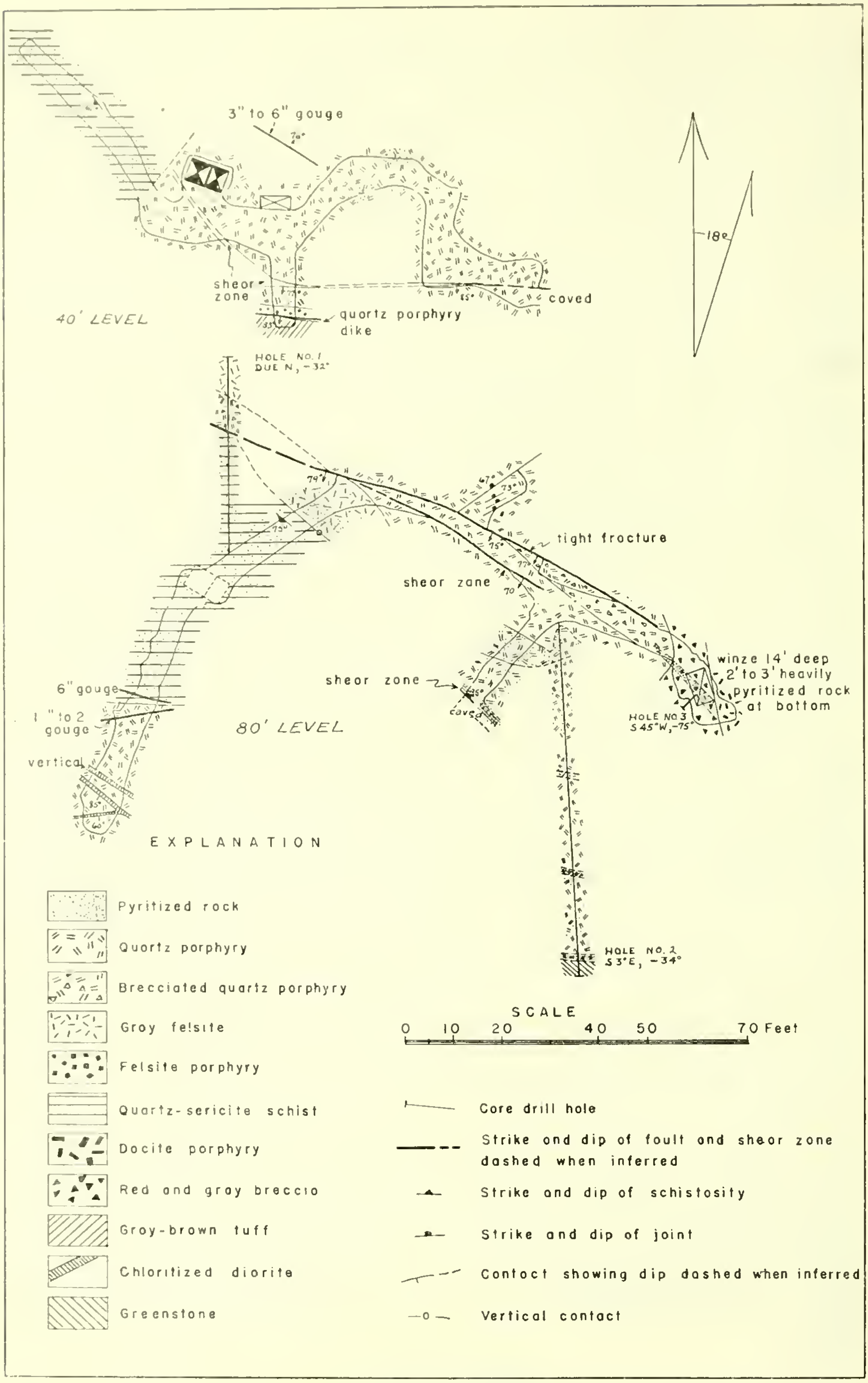

FIG. 2. Geologic map of the Gopher Hill mine, Calaveras County, California. Geology by G. R. Heyl, C. M. Gilbert, and J. B. Hadley, U. S. Geological Survey.

"While from the working of carefully prepared averages in considerable quantity by milling process, the tenor of the precious metals was:

Gold $29.18
Silver $ 5.91"

Using a price of $20.67 per ounce for gold and $1.30 per ounce for silver, Silliman's figures quoted above would correspond, respectively, to 1.70 and 1.41 ounces per ton for the gold content, and 11.60 and 4.55 ounces per ton for the silver content of the materials assayed. He gives no data on the base metals.

A smelter shipment of 505 tons of ore removed from the old stope above the 70-foot level, shown in section A-A′, assayed as follows: 6.22 percent copper; 21.0 percent zinc: 0.27 ounces of gold to the ton; and 5.68 ounces of silver to the ton. The upper portions of this stope lay within 70 feet of the original surface, and possibly closer. The copper and zinc content of this ore is somewhat higher than a 201-ton shipment from a sublevel 8 to 15 feet below the floor of this stope, which assayed as follows: 5.42 percent copper; 17.7 percent zinc; 0.44 ounces of gold to the ton; and 9.57 ounces of silver to the ton. Since the grade of this ore beneath the 70-foot level agrees fairly closely with the grade of ore obtained from the deeper portions of the mine, the presence of some secondarily enriched ore in the stope above the 70-foot level, at least in its upper portions, is suggested.

Byron E. Rowe, a former superintendent of the mine, has stated [8] that secondary chalcocite was present to a depth of about 60 feet beneath the surface, and below this depth very little was in evidence. It should be noted, however, that the writer has observed in the fault zones and immediately adjacent to them, as deep as the 205-foot level, a black powdery mineral lining vugs in the ore. This mineral gives positive blowpipe reactions for copper and sulphur, and is probably sooty chalcocite.

The early surface mining removed most of the gossan above this ore deposit, as well as the ore of the oxidized zone. This work resulted in three open-pits, the largest one probably having been used as a glory hole. Exposed in the smallest pit are three streaks of gossan, ranging from 1 to 20 inches in width; they are developed within an 8-foot zone in the light-colored, bedded tuffs immediately underlying the basalt contact. A narrow stope, now partly caved and extending downward about 40 feet along a 45° incline, was opened below this gossan which is made up of yellow-brown limonite with minor amounts of white quartz and barite. Stoped areas, presumably developed in ore, are the only known instances at Quail Hill where ore occurred in the hanging-wall volcanic rocks.

In the larger pits thin irregular streaks of gossan are still evident in the altered felsite. These streaks, particularly those away from the felsite contact, are commonly red-brown and siliceous; they contain numerous cubical holes that very probably represent leached out pyrite crystals.

Outlook

Because of the limited extent of the recent mining operations, little exploration has preceded actual mining. However, diamond drilling from the 270-foot level of the mine has indicated that the zone of strong

[8] Rowe, Byron E., personal communication.

mineralization, in which the known ore bodies occur, continues downward on its established trend. Nevertheless, none of these drill holes has explored the full width of the mineralized zone. The extension of this zone with depth, therefore, gives a promising outlook to the possibility of locating further ore bodies at the mine.

In prospecting for additional ore reserves, the most favorable ground is that lying along the trend of the downward extension of the strongly mineralized zone. The detailed mapping and examination of salients on the felsite contact exposed at the present erosion surface, and the location by geophysical methods of unexposed salients which may be present, are probably the most feasible methods for systematic prospecting at this locality.

GOPHER HILL MINE

The Gopher Hill mine is 6½ miles southwest of Copperopolis, and about half a mile southeast of the Quail Hill mine, near the western edge of the Sierra Nevada foothills (pl. 1). It consists of a vertical shaft and two short levels at 40 and 80 feet from the collar.

In 1943 the mine was unwatered by the Calaveras Consolidated Copper Company of Copperopolis, and three exploratory holes were drilled from the bottom level of the mine in search of copper and zinc ore. The results of this drilling are shown in fig. 2. No sulphide bodies of economic value were intersected by the drill holes and none was seen in the mine workings. Occasional specimens of sphalerite and chalcopyrite may be picked up from the mine dump. Copper staining is present on some of the walls of the mine, and is strongest in the drift of the 40-foot level extending northwestward from the shaft.

The Gopher Hill mine is located close to the northern margin of an irregular quartz porphyry intrusion, 500 to 700 feet in diameter. The quartz porphyry is intruded into the Amador (?) group (Jurassic) of volcanic rocks, which in the vicinity of the mine includes bedded tuffs, volcanic breccias, and lavas. The mine is at approximately the same stratigraphic horizon as the near-by Quail Hill mine, which has a somewhat analogous location along the edge of a felsite intrusion.

At the Gopher Hill mine strong shear zones, generally with a northwesterly trend and steeply dipping, are developed in the quartz porphyry and in gray felsite that is probably another facies of the intrusive rock. This shearing has apparently been most intense within the intrusion, close to its margin. In places sericitization has been intense, and has resulted in the development of fine-grained quartz sericite schist.

Along shear zones and elsewhere in the more strongly schistose rocks, much finely disseminated pyrite has been introduced. These strongly pyritized zones generally carry some gold and silver; mine records show assays of samples that range from $0.85 to $14.00 per ton in gold, and from 0.01 to 39.0 oz. per ton in silver. Because neither copper nor zinc ore was observed in place, and as the assays of the drill cores showed only very small amounts of these metals to be present, this mine is believed to hold little promise as a producer of copper or zinc.

NAPOLEON COPPER MINE

The Napoleon copper mine is about 6 miles southwest of Copperopolis, California, on the north flank of Hog Hill, and within a mile or so of the western edge of the Sierra Nevada foothills (pl. 1). The mine is

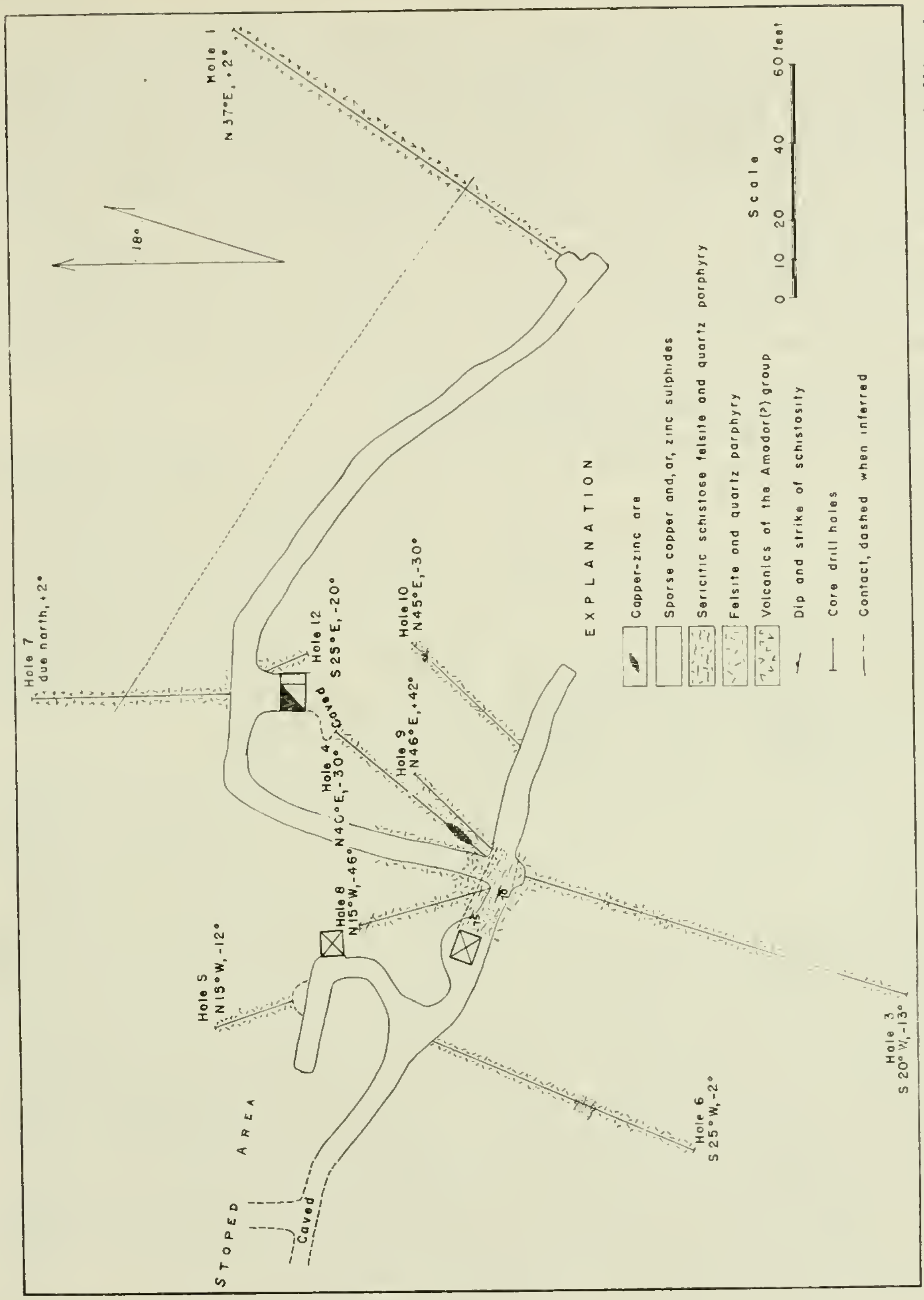

FIG. 3. Geologic map of the accessible portion of the 250-foot level, Napoleon mine, Calaveras County, California. Geology by G. R. Heyl and J. B. Hadley, U. S. Geological Survey, 1943.

adjacent to the contact between a large mass of intrusive quartz porphyry and felsite, and a relatively narrow belt of Amador (?) (Jurassic) volcanic rocks that trend approximately east (pl. 45). At the mine this belt is locally interrupted by the intrusion, the volcanic rocks forming several isolated areas or roof pendants. In this marginal zone of the intrusive mass are areas of quartz porphyry breccia that possibly represent the earliest portion of the magma to solidify.

The rocks of the Amador (?) group in the vicinity of the mine consists of andesitic lavas that in general are aphanitic, and in some places vesicular or amygdaloidal. A minor porphyritic facies characterized by euhedral phenocrysts of plagioclase, is particularly evident in the western part of the area. These volcanic rocks have undergone low-grade metamorphism to greenstones and green schists.

The mineralized area is in a shear zone, 6 to 30 feet wide, in the quartz porphyry and felsite, close to the contact of the intrusive mass with volcanics of the Amador (?) group; this shear zone, (not shown on plate 45, except by a line between the vertical shaft and open cuts) which cuts across the regional schistosity, strikes N. 75°W., and dips 65° to 75° southwest. There has been considerable sericitization in the shear zone, and a lesser amount in the adajcent rocks. The chief sulphide minerals are chalcopyrite, sphalerite, and pyrite, with gangue of barite, calcite, and quartz. A small amount of galena has been noted occasionally, and appreciable amounts of gold and silver are present.

The Napoleon mine is approximately 430 feet deep, with four main levels at 100, 250, 300, and 375 feet. Two of the three shafts are caved, the main shaft being completely obliterated at the surface by dump material. In 1942-43 the Mountain Copper Co., Ltd., rehabilitated the third shaft, a vertical one at the eastern end of the mine; it is 280 feet deep and connects the surface with the 250-foot level of the mine. A portion of this level was cleaned out and ten test holes drilled. the results being shown on the accompanying map (fig. 3). Two additional holes were drilled from the surface (pl. 45). The remainder of the mine has been inaccessible since 1919, when mining operations were discontinued.

Old maps, sections, and records of the mine indicate that three ore bodies of irregular lenticular shape were mined. The largest of these was the Discovery ore body, which is reported to have been 60 to 70 feet long, 6 to 20 feet wide, and mined to a depth of 250 feet or more; two smaller lenses below this, between the 250- and 375-foot levels, were also mined. The stoped out areas in the mine suggest that these lenses, individually and as a group, had an eastward pitch of 65° to 70°.

The mineralization at the Napoleon mine is similar in many respects to that at the Quail Hill mine, the Penn mine, and others in the Foothill belt. It is characterized by intimately intergrown copper, zinc, and iron sulphides that carry gold and silver, with barite among the gangue minerals, and sericitization an important wall-rock alteration. It is a replacement deposit developed along a shear zone, the shear zone having been formed close to the contact of a relatively large body of intrusive quartz porphyry and felsite.

COLLIER ZINC-COPPER MINE

The Collier zinc-copper mine is about 6 miles southwest of Copperopolis and a mile southeast of the Napoleon mine (pl. 1). It was first opened in the 1860's, when some gold was recovered from the oxidized zone above the ore body. In 1917-18 the shaft was sunk to 58 feet, the 56-foot level developed, and some sulphide ore shipped. Development work was carried on by E. A. Vogt, lessor, during 1942 and regular shipments were made from May 1943 until July 1944. During this period two additional levels were developed and 5613 tons of ore produced. The grade of this ore is summarized as follows:[9]

Gold, ounce per ton	0.070— 0.112
Silver, ounces per ton	2.94 — 4.92
Lead, percent	0.26 — 0.91
Copper, percent	1.17 — 1.90
Zinc, percent	8.75 —13.46

The mine consists of a shaft with an average inclination of 51°, with levels at 56, 124, and 167 feet on the incline (pl. 46). An abandoned shaft, not connected wtih the accessible mine workings, lies 150 feet southeast of the main shaft.

The mine is developed along a fault zone, which follows or is close to the contact of intrusive quartz porphyry with volcanic greenstones and bedded tuffs of the Amador (?) group (Jurassic). The ore body is a replacement sulphide lens which has as its footwall the east-dipping high-angle fault. This fault has numerous subsidiary spur faults in its hanging wall; in addition, there are several cross faults that offset the footwall fault as well as the ore. The footwall fault dips eastward from 44° to 70°, the ore body having formed along a portion of the fault surface where its dip is relatively low, the ore pinching out where the dip approaches the higher angle. The position of the ore body on the several levels, and the plunge of its margins, indicate a northward plunge of approximately 43° for the lens as a whole.

The ore consists of an intimate mixture of chalcopyrite, sphalerite, and pyrite, with barite as an abundant gangue mineral. The footwall of the ore body, and locally the hanging wall, is strongly to moderately pyritized; this pyritization extends for appreciable distances along the strike, beyond the pinching border of the lens. The effects of oxidation are apparent for 36 feet below the surface, just above the 56-foot level of the mine, and secondary chalcocite is reported to have been present as staining films and thin seams to depths as great as 60 feet.

During the summer of 1944 the U. S. Bureau of Mines drilled two holes exploring the ground below the Collier mine workings, and two additional holes 825 and 975 feet to the northwest under shallow workings of an abandoned mine known as the Little Quail Hill. All these holes disclosed the presence of zinc, copper, gold, and silver minerals, but no commercial ore was intersected.[10]

STAR-EXCELSIOR MINE

The Star-Excelsior mine is an inactive mine 6½ miles southwest of Copperopolis and approximately one mile south of the Napoleon mine. The mine is reported to have been operated for a short period in the late twenties. The mine consists of three shafts, two tunnels, and several smaller openings. These workings, some of which are accessible, are in intrusive quartz porphyry, within a few hundred feet of its contact with

[9] Collier mine, Calaveras County, California: U. S. Bur. Mines War Minerals Rept. 346, pp. 3-6, 1944.
[10] U. S. Bureau of Mines, op. cit., p. 1.

Jurassic volcanics of the Amador (?) group. The most prominent zone of mineralization is marked by an area of gossan and silification 10 to 50 feet wide, and at least 350 feet long, developed in sheared and brecciated quartz porphyry. Another zone of mineralization lies a short distance east of this one. Sphalerite, chalcopyrite, and pyrite are the common sulphide minerals, and such secondary products as malachite, azurite, chrysocolla, and chalcocite are present. Barite occurs as a gangue mineral, and kaolinization has affected the wall rocks.

LA VICTORIA COPPER MINE, MARIPOSA COUNTY, CALIFORNIA *

By Manning W. Cox ** and Donald G. Wyant **

OUTLINE OF REPORT

ILLUSTRATIONS

ABSTRACT

The copper deposit of La Victoria mine at Hunter Valley, Mariposa County, California, is along a narrow shear zone in greenstone. The ore-bearing zone, which trends north to N. 50° W. and dips 10° to 45° E., is in a fracture in the hanging wall of the steeper Poupion shear zone. Within the ore zone copper carbonate and sulphide ore occurs as pods about 2 feet wide and as much as 15 feet in strike length.

The ore zone has been mined along a maximum stope length of 140 feet and for 250 feet down the dip. Most of the ore mined contained supergene copper minerals in addition to hypogene chalcopyrite. The enriched ore is believed to be exhausted; primary sulphide ore probably continues below the old stopes. No strike extension of the deposits is believed to exist, but copper ore may occur in a parallel shear zone near the Cavagnaro shaft.

INTRODUCTION

La Victoria copper mine at Hunter Valley, Mariposa County, California, is an old property in the foothills of the Sierra Nevada, about 4 miles west of the Mother Lode gold belt. The property is in parts of sections 4, 9, and 10, T. 4 S., R. 16 E., Mt. Diablo base and meridian.

The mine is most easily reached from Hornitos, Mariposa County, by 11 miles of graded road that extends to within one mile of the mine. A nongraded truck trail reaches the mine from this point.

The area is explored by numerous pits, shallow shafts, and underground workings, shown on plates 47 and 48. The only accessible shaft is the Cavagnaro to the west of the mine workings (pl. 47). Access to underground workings is gained by two adits, one on the Adit level, the other on the Main level.

The underground workings comprise 785 feet of drifts, crosscuts, and inclines limited to La Victoria ore zone. The deposit is developed for a distance of 250 feet along the dip by workings on four levels: the Adit level, elevation 1,958 feet; the Intermediate level, elevation 1,931 feet; the Main level, elevation 1,900 feet; and the Bottom level, elevation 1,858

* Published by permission of the Director, Geological Survey, U. S. Department of the Interior. Manuscript submitted for publication March 1, 1948.

** Geologist, Geological Survey, U. S. Department of the Interior.

feet. The Old, New, and Lang shafts, now caved, formerly connected with the accessible workings. Most of the ground above the Bottom level has been stoped and is filled or caved.

The surface area and the accessible workings were mapped by the writers in May and October 1944 as part of the U. S. Geological Survey's wartime investigation of the Foothill copper-zinc belt. The workings below the Main level were flooded.

Mr. R. B. Lamb has kindly allowed the use of an assay map of the mine, made in 1943 by Messrs. Quenton Brewer and Frank Casaccia. This map, together with a few check samples taken by the writers, provided the basis for estimating the grade of the deposit. The outlines of the lower workings are taken from the assay map.

The report has benefited from many helpful suggestions by G. R. Heyl.

HISTORY AND PRODUCTION

The copper deposits are said to have been discovered in April 1864 and explored by La Victoria Mining Company. The company and its immediate successors mined and sorted high-grade ore for direct shipment and also erected a small furnace on the property to treat the low-grade ore. Activity at the property ceased in 1873, by which time most of the ore was stoped. In the 1890's and again in 1917 some sorted ore from the old stopes and dumps was shipped. The mine belongs to the estate of the late Herbert Lang.

Aubury [1] stated, in 1908, that the total production in 1864 and 1865 was over 2,000 tons of sorted ore and 2,000 tons of ore treated at the mine, partly by roasting and leaching and partly by smelting. The size of underground openings and mine dumps indicates that little ore has been removed since that time.

Between May 1943 and March 1944, R. B. Lamb leased the property and partly rehabilitated the mine workings and sampled the ores with the aid of an RFC loan.

GENERAL GEOLOGY

La Victoria mine is in an area underlain by slightly metamorphosed volcanic rocks and chert, assigned by Taliaferro [2] to the Jurassic Amador group. According to Taliaferro [3] the area is near the crest of a large anticline that trends northwest and plunges gently to the southeast. The overturned west limb of the anticline is cut off by the Piney thrust.

COUNTRY ROCKS

Greenstone, predominantly with pillow structure, is exposed for at least 1,000 feet to the east and west of the mine. The rock is made up of closely packed irregular pillows that range in diameter from a few inches to 4 feet. Many pillows are surrounded by a thin shell of mudstone or by epidote masses. A few masses of breccia composed of greenstone and red jasper occur between pillows.

The greenstone is a green-gray fine-grained granular rock with little cleavage. Minerals visible in the rock are augite, chlorite, epidote, and

[1] Aubury, L. E., Copper resources of California: California Min. Bur. Bull. 50, p. 265, 1908.

[2] Taliaferro, N. L., Bedrock complex of the Sierra Nevada, west of the southern end of the Mother Lode (abstract): Geol. Soc. America Bull., vol. 44, pp. 149-150, 1933.

[3] Taliaferro, N. L., Manganese deposits of the Sierra Nevada, their genesis and metamorphism: California Div. Mines Bull. 125, p. 304, 1943.

feldspar. Similar rocks from Merced River Canyon have been studied by Taliaferro who describes them as follows:[4]

> "Augite is the predominant mineral, being much more abundant than plagioclase, which is usually altered . . . Plagioclase, usually albite-oligoclase, occurs sparingly both as small lath-shaped crystals and intergrown with feathery augite . . . these appear to be typical pillow basalts or spilites."

The rocks near the mine contain abundant chlorite and epidote and are probably more altered than those investigated by Taliaferro. The name greenstone is therefore used in this paper.

STRUCTURE

Individual flows of pillow lava are recognized by Taliaferro north of the mine but within the area mapped (pl. 47), the greenstone could not be subdivided. Layers of pillows in greenstone strike approximately N. 20°-65° W. and dip from 20° to 50° E.

Many faults and shear zones, probably with small displacement, occur in the area. The faults are marked by slickensides, gouge, and a finely spaced fracture cleavage in the adjoining rocks. Narrow calcite and quartz-epidote veins follow many faults. A few structures that are mapped as faults (pl. 48), show no direct evidence of movement; however, they do contain quartz-epidote veins similar to those in known faults. The shear zones range in width from a few inches to 12 feet and are composed of closely spaced faults that do not persist more than a few tens of feet along the strike.

The faults and shear zones belong to two major systems: (1) faults with a N. 60°-80° W. strike, most of which dip steeply northward, but a few of which dip southward; and (2) faults which strike north to 50° W. and dip 10°-50° to the northeast. A few faults strike east of north and dip either eastward or westward, most of them less than 60°.

The most prominent shear zone of the first system is the Poupion shear zone, which is well exposed at the collars of the New and Old shafts. This zone can be traced westward from the New shaft 400 feet to the Cavagnaro shaft and may continue 800 feet farther west to the Northwest shaft. In the mine workings it extends to the southeast from the New shaft for a minimum length of 100 feet. The zone is from 2 to 12 feet in width and dips 65°-87° northward. No ore deposits are known along this zone.

La Victoria ore zone, exposed for 125 feet along the Main level, is the most important shear zone of the second system. It extends northward from the Poupion shear zone to the north end of the mine workings where it diminishes in width and probably dies out. The strike of the zone bends from north near the Poupion shear zone to N. 50° W. at the north end of the mine workings. Its dip is 10°-45° eastward. In the north raise, near the Intermediate level (pl. 49, section 1-1′), the ore zone bends vertically into steeply dipping shears which strike northwest. A structure contour diagram of the ore zone and associated barren shears (fig. 1) indicates the sigmoid shape of the zone. It further suggests that before erosion the zone may have pinched out upward against the Poupion shear zone, just west of the Old shaft collar.

Near the Cavagnaro shaft is another shear zone that belongs to the second system. The zone strikes N. 45° W. and dips 30°–60° to the north-

[4] Taliaferro, N. L., idem, pp. 304, 321.

east. It is not more than one foot in width. The structure contours of this zone are also shown in figure 1. The possibility exists that if the dip of this zone flattens in depth, the zone could connect with La Victoria ore zone. The zone, however, may lie entirely in the footwall of La Victoria ore zone.

ORE DEPOSITS

La Victoria Ore Zone

Carbonate-sulphide copper ore was stoped in La Victoria ore zone to a distance of 250 feet down the dip. The sulphides were completely oxidized to below the Adit level, about 30 feet vertically from the outcrop, and copper was leached for at least 20 feet of this distance. The existence of partly oxidized ore to a minimum depth of 80 feet vertically is proved by its presence on the Main level, the present level of ground water.

Some gossan is exposed at the Old and New shaft collars, and on the Adit and Intermediate levels. The most abundant type is a porous mass of fine-grained quartz, stained red-brown by iron oxide that coats cubic pits and floods the rock. Some soft earthy red and yellow iron oxide occurs separately, as well as with the quartz gossan. Gossan masses range in thickness from a fraction of an inch to 2 feet, and in strike length from a few inches to more than 15 feet.

Below the Adit level the carbonate-sulphide ore is exposed in pillars and walls down to the Main level. Pyrite, chalcopyrite, and clear quartz, and supergene azurite, malachite, and chalcocite were observed in the ore. Assays indicate from a trace to 2.1 percent zinc; sphalerite was not identified. Small amounts of gold, in general less than 0.1 ounce per ton, are shown by assays to be present also in the ore. Chalcocite occurs in fractures and around grains of the other sulphides. The copper carbonates are in small patches in the sulphides. The primary ore is massive and fine-grained, containing abundant pyrite intergrown with quartz and some chalcopyrite.

Along the north end of the old stopes the carbonate-sulphide ore passes into quartz-pyrite rock. Assays indicate this material contains 1 percent copper or less. No copper carbonate and very little chalcocite are visible in the rock. The quartz and pyrite form colloform layers in which quartz makes up from 30 to 90 percent of the rock. The quartzose gossan is probably derived from this type of primary deposit.

The ore stoped down to the Bottom level was probably moderately enriched by supergene minerals. The average copper content of pillar samples decreases from 5.3 percent in the upper mine levels to 4.1 percent on the Bottom level; this decrease may reflect decreasing enrichment with depth. The ore below the Bottom level probably consists principally of hypogene minerals.

The ore and gossan occur along La Victoria ore zone in pods that range from a few inches to 15 feet in long dimension. Most pods are in sheared greenstone partly replaced by quartz, but one pod lies between pillows in unsheared greenstone. The pods range from less than 1 foot to 3.2 feet in width and average about 1.5 feet. Five-foot widths of ore, reported by J. R. Browne in 1868,[5] were not seen by the writers, but they may have occurred where copper carbonates migrated into the footwall of the sulphide deposits.

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[5] Browne, J. R., Mineral resources of the States and Territories west of the Rocky Mountains for 1867, pp. 207-219, 1868.

The ore pods are exposed in La Victoria ore zone north from the Poupion shear zone for 80 to 140 feet. In the north raise near the Intermediate level sulphides in the ore zone pinch out along the steeper parts of northwest trending faults. On the Main level, near the Badger Hole workings, ore pods are at the intersection of faults in the hanging wall of La Victoria ore zone.

The copper-bearing ore shoot is generally restricted to the part of the ore zone that strikes north to N. 15° W. The more westward trending portion of the ore zone contains principally quartz-pyrite rock. The stopes, plotted on the structure contour diagram (fig. 1) coincide with this northward trending part.

The strike length of the northward trending part of the ore zone is 20 feet at the surface, 125 feet on the Main level, 110 feet on the Bottom level. This ore shoot probably extends some distance below the mine workings and is the most favorable ground for exploration. Little strike extension of the ore zone is to be expected because the zone is bounded on the south by the Poupion shear zone and appears to die out to the north.

Other Mineralized Shear Zones

Gossan occurs along shear zones in many of the pits and shafts west of La Victoria ore zone. However, most of the gossan is the type derived from quartz-pyrite rock. The only gossan believed to represent primary copper sulphide ore occurs in the narrow shear zone just east of the Cavagnaro shaft. This gossan is poorly exposed and at but one place; it would have to be uncovered to permit proper evaluation.

Narrow stringers of quartz gossan occur along the Poupion shear zone but do not indicate copper ore.

Origin and Localization of the Deposits

The primary sulphide deposits are localized along gently dipping shear zones in the hanging wall of the steeper Poupion shear zone. The hypogene solutions may have risen along the steep shear zone, and deposited the ore minerals in the more gently dipping shears.

The supergene copper carbonate and sulphide minerals were formed by oxidation and enrichment of the lower-grade hypogene sulphide mass. The moderate grade of the enriched ore is probably due in part to unfavorable physiographic conditions during the recent geologic history of the deposit—high ground-water level and rapid erosion do not favor deep or great enrichment. In addition, only a small volume of material from which copper for enrichment could be derived was available above the present ground surface, if La Victoria ore zone terminated upward only slightly above the collar of the Old shaft, as is suggested by the structure contour diagram (fig. 1).

EXTENSION OF DEPOSITS

The enriched ore of La Victoria mine is nearly exhausted; a small amount may remain in pillars above the Bottom level. The grade of pillar samples is about 5 percent copper.

The ore shoot in the northward trending part of the ore zone continues below the present mine workings. This ore shoot is not over 2 feet in width and may have a strike length on the Bottom level of 110 feet. The average grade of the primary ore on the Bottom level, 4 percent copper, may represent the grade of the ore below.

The mineralized shear zone just east of the Cavagnaro shaft is the only other shear zone that appears to carry copper minerals.

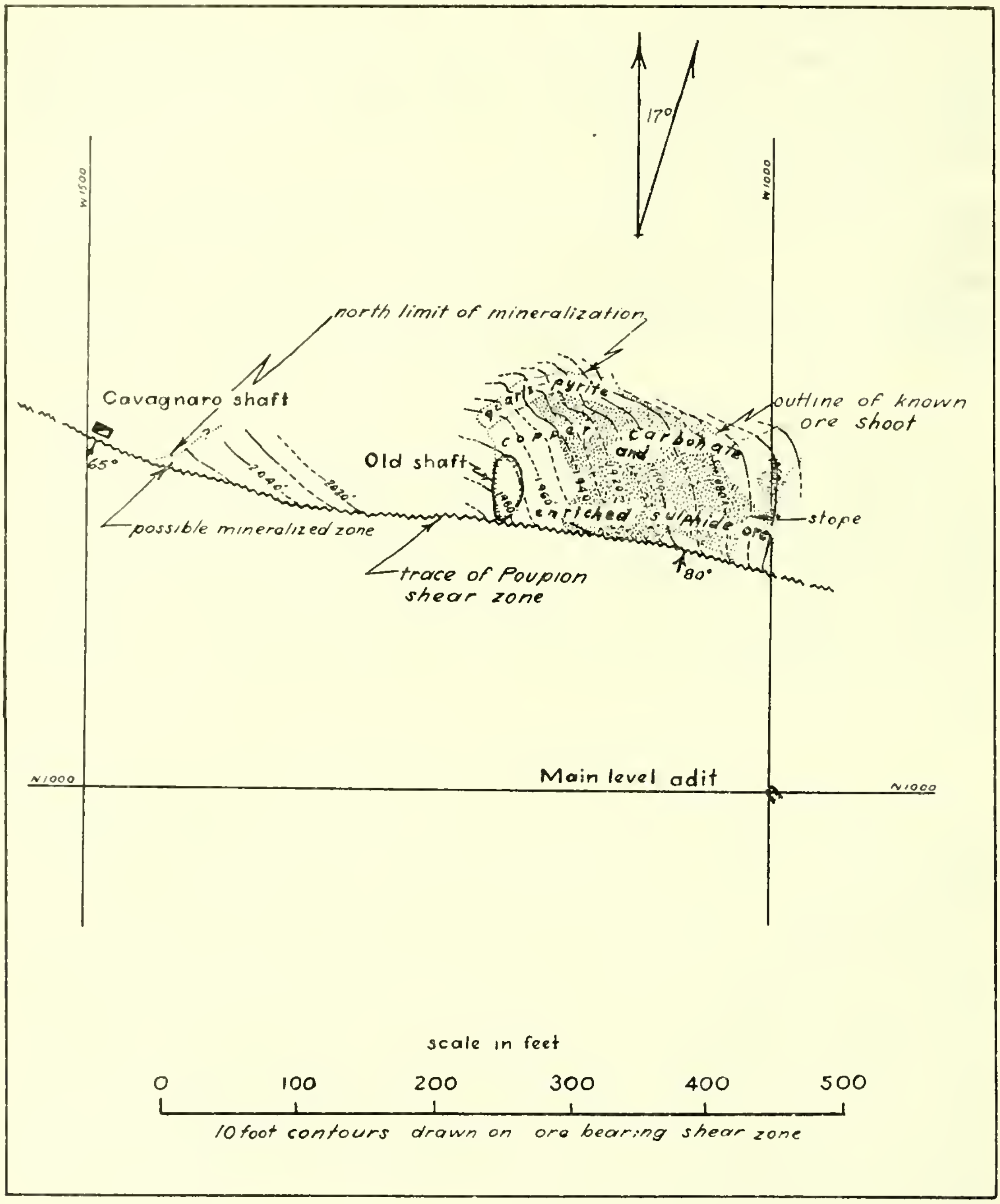

FIG. 1. Structure contour diagram of the mineralized zones, La Victoria mine, Mariposa County, California; D. G. Wyant and M. W. Cox, U. S. Geological Survey, May 1944.

ZINC DEPOSITS OF THE AMERICAN EAGLE-BLUE MOON AREA, MARIPOSA COUNTY, CALIFORNIA *

By John H. Eric ** and Manning W. Cox **

OUTLINE OF REPORT

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ILLUSTRATIONS

ABSTRACT

The American Eagle-Blue Moon area, in Mariposa County, California, includes the American Eagle prospect, and the Blue Moon mine from which zinc-lead-copper ore was produced from 1943 through 1945. The principal stratigraphic units of the area are chlorite schist, felsite, and slate; the intrusive rocks include greenstone and felsite porphyry. These units trend west of north and dip steeply either eastward or westward.

Along part of the contact between chlorite schist and felsite the rocks are silicified, sericitized, and pyritized. In the sericitized rocks steeply dipping shear zones locally contain abundant sulphides and form mineralized zones. Sphalerite, pyrite, tetrahedrite, galena, chalcopyrite, and some gold occur in a gangue of sericite, barite, quartz, and calcite.

In 1899 the American Eagle prospect produced an appreciable quantity of gold. No economic deposits of zinc are known here, but areas favorable for exploration exist.

In 1935 the Blue Moon mine produced a small amount of gold-silver-copper ore. In 1940 zinc deposits were discovered. Three elongate, northward pitching ore bodies occur in two westward dipping mineralized zones. During 1944-45 more than 50,000 tons of ore was produced, averaging 14 percent zinc and containing a little lead, copper, silver, and gold. Undeveloped zinc deposits lie just west of the mine.

INTRODUCTION

Economic zinc deposits were discovered in 1940 six miles north of Hornitos, Mariposa County, California (fig. 1). The area near the deposits, herein referred to as the American Eagle-Blue Moon area, is in secs. 19 and 30, T. 4 S., R. 16 E., Mt. Diablo base and meridian. A topographic map of the Merced Falls 15-minute quadrangle, published in 1944 by the U. S. Geological Survey, shows the location of the Blue Moon mine, erroneously called the "Blue Cloud mine," near the southeast corner of the quadrangle. In 1943-45 the American Eagle prospect was inactive; the Blue Moon mine was operated by Red Cloud Mines, Inc.

The area is 4 miles north of the county highway between Hornitos and Bear Valley, and is reached by a gravel road.

Merced, 40 miles to the southwest, is the nearest rail shipping point.

The area lies in the western foothills of the Sierra Nevada about 4 miles east of the edge of the San Joaquin Valley and one mile east and south of the Merced River. The properties are at an elevation of about 1,200 feet, along a north-trending ridge that rises 400 feet above rolling hills to the east and west.

The American Eagle-Blue Moon area is part of the Sonora quadrangle, studied in 1894 by H. W. Turner and F. L. Ransome.[1] More

[1] Turner, H. W., and Ransome, F. L.: U. S. Geol. Survey Geol. Atlas, Sonora folio (no. 41), 1897.

recently N. L. Taliaferro has made a reconaissance re-examination of part of the Sonora quadrangle.[2]

The American Eagle-Blue Moon area was studied during part of 1943-45 as part of the U. S. Geological Survey program of investigation of the Foothill copper-zinc belt. In October 1943, G. R. Heyl of the U. S. Geological Survey made a preliminary examination of the properties. Diamond-drill holes, put down at the American Eagle prospect by the U. S. Bureau of Mines, were later logged by Survey geologists. In February 1944 M. W. Cox mapped the Blue Moon workings and in September and October J. H. Eric and M. W. Cox mapped the surface area and other accessible workings. In October 1945 Eric visited the Blue Moon mine in order to bring maps and information up to date.

For many courtesies the writers are indebted to Mr. J. H. A. Williams, former lessee of the American Eagle prospect, and to officials of Red Cloud Mines, Inc., especially Mr. Robert H. Dunn, superintendent. Logs of company drill holes, assay data, and maps of the area have been made available. Geologic notes taken from company logs are the work of John Payne Jr., and R. E. Sorenson.

J. H. Eric has prepared the general section of this report and the discussion of the American Eagle prospect. The Blue Moon mine is described by M. W. Cox.

GEOLOGY

The American Eagle-Blue Moon area is part of an extensive region along the foothills of the Sierra Nevada (fig. 1) that is underlain by slightly metamorphosed volcanic and sedimentary rocks of pre-Cretaceous age. Granodioritic intrusives of the Sierra Nevada batholith are exposed in the Mariposa lobe, 12 miles southeast of the area. Recently Taliaferro[3] has divided the rocks of the surrounding region into the Mariposa and Amador groups, both of Jurassic age. Slate and arkose of the Mariposa form a narrow belt 4 miles west of the area, and, according to Turner and Ransome,[4] the Mariposa also crops out at the east edge of the area.

Character and Distribution of the Rocks

Three principal belts of slightly metamorphosed rocks cross the American Eagle-Blue Moon area from north to south (pl. 50). On the west are greenstone and chlorite schist derived from mafic tuff and volcanic breccia. The central belt is composed of felsitic volcanic rocks. On the east is black slate with a minor amount of quartzite and arkose. Several irregular dikes of felsite and greenstone intrude the volcanic rocks.

Greenstone and Chlorite Schist. The belt of greenstone and chlorite schist crops out over a width of at least 1,200 feet. The rock is dark-green to gray-green, moderately schistose, and is composed of chlorite, epidote, feldspar, ankerite, and quartz.

The more abundant of two principal types of chlorite schist is a breccia containing greenstone fragments with closely spaced spherical and ellipsoidal quartz amygdules. Because the amygdules resist weathering, many of the exposures have a characteristic lumpy appearance.

[2] Taliaferro, N. L., Bedrock complex of the Sierra Nevada, west of the southern end of the Mother Lode (abstract) : Geol. Soc. America Bull., vol. 44, p. 149, 1933.
[3] Taliaferro, N. L., Geologic history and correlation of the Jurassic of southwestern Oregon and California : Geol. Soc. America Bull., vol. 53, pp. 71-112, 1942.
[4] Turner, H. W., and Ransome, F. L., op. cit.

The second type of chlorite schist consists in part of tuff and in part of breccia composed of rounded and subangular fragments of greenstone in a tuffaceous matrix. Many greenstone fragments contain feldspar crystals which at the surface are partly weathered to clay. These rocks occur near the felsite contact in a belt about 200 feet wide in the south and central parts of the area but 500 feet wide farther north. The increase in width is probably due to interfingering of the two types of chlorite schist.

Near the south end of the area two beds of felsite conglomerate in the chlorite schist occur at a re-entrant in the contact between chlorite schist and felsitic volcanic rocks. A third bed lies on the chlorite schist-felsite contact at the north end of the area. This conglomerate probably indicates a local unconformity, and suggests that the chlorite schist is younger than the felsitic volcanic rocks.

Felsitic Volcanic Rocks. The central belt of felsitic volcanic rocks is the most resistant formation and underlies the prominent ridge in the central part of the area. The width of outcrop of the felsite ranges from 800 feet in the south part of the area to at least 1,000 feet near the north end. Two principal types of felsite, 1) schistose tuff and volcanic breccia, and 2) massive, nonfragmental felsite, grade into each other across the strike; nowhere is the contact sharp, nor does one type cut across the other. The contacts between the two types shown on plate 50 are therefore somewhat arbitrary and are based primarily on the presence or absence of schistosity. Away from the contact, however, the two types are readily recognized, for one is a fragmental rock and the other is not.

The tuff and breccia is a blue-gray to green-gray, schistose rock, containing appreciable sericite, and is characterized by abundant crystals of feldspar in the matrix and fragments. Most fragments have a diameter of 2 to 4 inches and are set in a fine-grained gray tuffaceous matrix. Many show flow banding with alternating layers, a fraction of an inch thick, of light- and dark-colored felsite; the flow banding is locally contorted. In the south part of the area tuff beds make up much of the unit, but farther north breccia is more abundant. Within the felsitic tuff and breccia are a few small lenses of bedded chlorite schist derived from mafic tuff.

The massive felsite ranges in color from blue-gray to black. Crystals of feldspar 0.5 to 2 millimeters in diameter are set in an aphanitic matrix that probably consists of quartz and feldspar, and tiny grains of pyrite are scattered throughout the rock. Flow banding is absent. The massive felsite has a poor foliation approximately parallel to schistosity in the tuff and breccia.

The gradational relationship between the two types of felsite suggests that the massive type is an extrusive rock. However, the texture and composition of the massive felsite is similar to that of felsite bodies known to intrude the Amador group in Calaveras County. Whether extrusive or intrusive in origin, the massive felsite is probably contemporaneous with the tuff and breccia.

Black Slate and Quartzite. The sedimentary rocks lying east of the felsite were mapped only in reconnaissance fashion. Immediately east of the felsite is 10 to 40 feet of greenish chloritic arkose, then 200 feet of dark-gray to black quartzite, and finally an undetermined width of black slate. Much of this unit is well bedded, in contrast to the almost complete absence of bedding in the volcanic rocks.

Greenstone Dikes. Two narrow irregular greenstone dikes are exposed at the surface and similar dikes occur in the underground workings. One of these dikes, near the Blue Moon mine, ranges in width from 5 to 60 feet and is about 700 feet long; a larger one, in the southeast part of the area, ranges in width from 15 to 100 feet and has been mapped along the strike for 1,000 feet. The greenstone is dark green and moderately schistose; minerals visible to the naked eye are chlorite, epidote, and feldspar. The greenstone dikes exhibit the same amount of deformation and grade of metamorphism as the enclosing rock.

Felsite Dikes. Two bodies of hornblende felsite porphyry intrude chlorite schist about 1,000 feet west of the felsite contact, and near the Blue Moon mine two dikes of similar rock cut across the felsite breccia and chlorite schist. Parts of these dikes are silicified and poor foliation is developed in the rock at several exposures.

The hornblende felsite porphyry contains spots of dark chlorite and phenocrysts of feldspar and acicular hornblende in an aphanitic greenish-gray groundmass. The feldspars are as much as 2 millimeters long but the hornblende crystals are visible only under magnification. The rock is similar, except for the hornblende, to the massive felsite of the volcanic rocks, and these dikes may represent a deeper-seated facies of the same igneous sequence.

Two dikes of blue-gray felsite identical to massive felsite of the volcanic rocks occur in chlorite schist, one west of the Blue Moon mine, the other northwest of the American Eagle prospect.

Rock Alteration

Parts of the volcanic rocks and some dikes have been sericitized, silicified, and pyritized, and veins of quartz and jasper have been introduced into altered and unaltered rock. The locus of this hydrothermal alteration is the contact between felsite and chlorite schist, and the rocks in an elongate zone near the center of the area were affected by the solutions. The main alteration zone is half a mile long and as much as 800 feet wide. It lies in both felsite and chlorite schist in the central part of the area, but the northern and southern ends are restricted to felsite. A few smaller bodies of sericite schist occur within several hundred feet of the main zone. In a very general way the main alteration zone consists of a core of silicified rock enclosed in sericitized rock. The alteration affects all types of rock near the felsite-chlorite schist contact and in detail follows along schistosity planes; thus the alteration is probably later than regional metamorphism.

Weathering, possibly augmented in the alteration zone by oxidation of sulphides, has transformed part of the sericitized rock into clay. Where this supergene alteration is intense, as in schist exposed by the American Eagle adit, the rock is a mixture of quartz and clay.

Sericitized and Silicified Rocks. The altered rocks grade from white quartz rock to quartz-sericite schist and sericite schist. Rocks containing more sericite than quartz are mapped as sericitized; those with 50 percent or more of quartz, as silicified. Stringers and disseminations of pyrite occur throughout the altered rock, but are most abundant in altered chlorite schist.

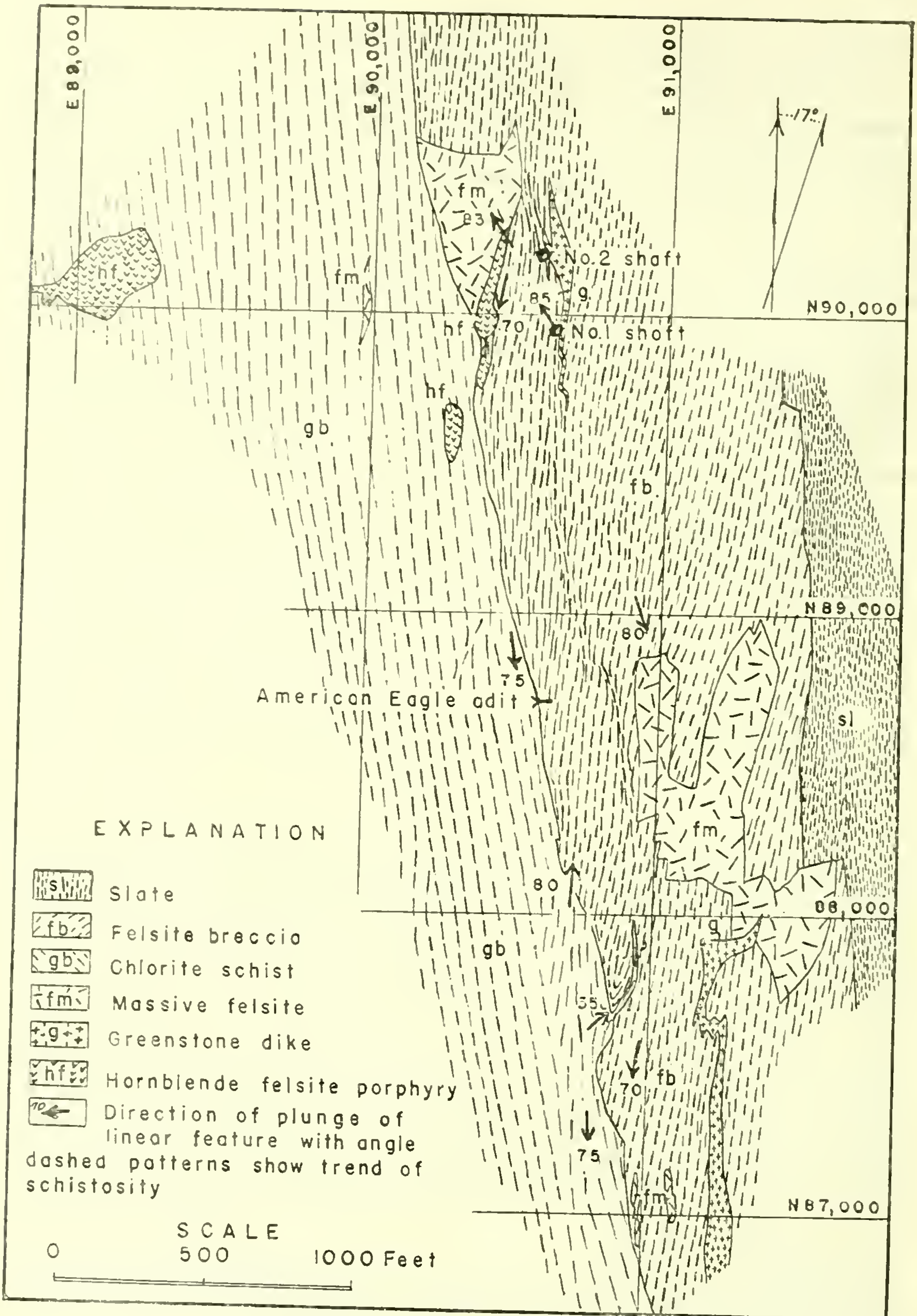

FIG. 1. Tectonic map of the American Eagle-Blue Moon area, Mariposa County, California.

The sericitized rocks are light-gray schists that locally contain films of slickensided pyrite. Sericitized felsite can be distinguished from schistose but relatively unaltered felsite by its lighter color, abundance of sericite, and absence of feldspar crystals.

The silicified rocks are cream-colored to white. Most of them contain sufficient sericite to be schistose, but schistosity is poorly developed in the intensely silicified rocks that crop out at the top of the hill above the American Eagle adit. Silicified chlorite schist can be recognized by the presence of quartz amygdules; silicified felsite breccia by relict flow banding.

Quartz-Pyrite Rock. With increase in the amount of pyrite and clear quartz, the altered rock grades into the quartz-pyrite rock exposed east of the portal of the American Eagle adit. Because the rock is relatively massive, unaltered pyrite exists at the surface. Much of the pyrite, however, is oxidized and exposures of quartz-pyrite rock have a characteristic brownish-red color.

Many veinlets of similar rock exist, particularly in altered chlorite schist, but are too small to be shown on the surface map, plate 50. In the area explored by Red Cloud Mines drill hole 1, both silicified and sericitized chlorite schist contain as much as 10 percent of these veinlets. Small quantities of sulphides other than pyrite occur in the veinlets; assays of 105 feet of core from hole 1 average about 0.5 percent combined zinc and copper.

Jasper. In the south part of the area hematitic jasper occurs in chlorite schist and along the contact between felsite and chlorite schist. The veins range in width from a few inches to 7 feet, and apparently consist of red quartz and intergrown reddish hematite, with thin laminae of specular hematite parallel to the slickensided vein walls. The country rock is replaced by jasper, possibly along a small fault or shear zone.

Quartz Veins. Veins of milky quartz containing only a small quantity of pyrite or iron oxide occur in the altered rocks. The most prominent quartz vein, about 10 feet wide, is in silicified rocks along the contact between chlorite schist and felsite north of the American Eagle adit. Similar veins containing chlorite occupy faults that deform the ore at the Blue Moon mine. Some of these veins are thus younger than the ore deposits.

Structure

The region is one of considerable folding,[5] but no major fold axes occur within the American Eagle-Blue Moon area. However, the rocks are steeply tilted, as shown on plate 51, which suggests that they may lie on the limb of a major fold. If the felsite pebbles in chlorite schist indicate younger rocks to the west, the area may lie on the west limb of a major anticline. On the other hand, the structure may be a homocline, bounded by one or more faults.

Bedding. The principal stratigraphic contacts trend north to N. 20° W., except for local irregularities. Bedding in the slate strikes essentially parallel to these contacts and dips steeply. The rock units in the south part of the area dip eastward, but near the Blue Moon mine the contacts are inclined westward.

Schistosity. The dip of the schistosity is roughly parallel to the stratigraphic contacts, for its direction changes from eastward south of

[5] Taliaferro, N. L., Manganese deposits of the Sierra Nevada, their genesis and metamorphism: California Div. Mines Bull. 125, pp. 277-332, 1943.

the American Eagle adit to westward near the Blue Moon mine. Except for local surface slumping the dip is more than 75°. Generally the schistosity strikes east of north in felsite and slate, west of north in chlorite schist. However, locally the strike is changed by shearing, as shown on fig. 1.

Lineation. In altered rock that contains appreciable sericite, minute crinkles are developed along schistosity planes, and many breccia fragments in chlorite schist and felsite are elongated. Both crinkles and long axes of fragments plunge [6] more than 70°. At the Blue Moon mine these linear elements plunge northward; elsewhere they generally plunge southward.

Folds and Faults. Minor folds in schistosity occur in the altered rock and immediately adjacent chlorite schist. These schistosity folds are small, with a wave length of a foot or two. They plunge steeply, generally more than 50°, to the north or south and are probably due to shearing with a large horizontal component.

The irregularities in the slate-felsite contact, and some re-entrants of chlorite schist into felsite may be caused either by folds or by transverse faults of small displacement, or by both. Because the irregularities in the contacts do not appear to form a pattern suggestive of transverse faulting, these irregularities have been mapped as minor folds rather than faults. No transverse faults were seen in underground openings.

A zone of reverse faults in the Blue Moon mine, described below, deforms or destroys the ore, but it is apparently a series of minor slips confined to the margin of the deposits. Several minor reverse faults marked by gouge, slickensides, or breccia are exposed elsewhere in mine workings.

Shear Zones. Certain narrow, elongate areas of altered rock are characterized by extreme fissility, particularly in sericite schist, and by crumpled and contorted schistosity. In detail these narrow zones cut across schistosity in the surrounding rocks. They are believed to be pre-ore shear zones, and are best developed in narrow bodies of sericite schist and along the margins of wider bodies, presumably because sericite schist is the least competent rock. The most prominent zone of shearing, about 1,000 feet long and 1 to 10 feet wide, is localized along the contact between sericitized and silicified felsite breccia east of the portal of the American Eagle adit, and several such zones are exposed along the greenstone dike at the Blue Moon mine.

These deformed areas, shown diagrammatically by the trend of schistosity of figure 1, strike north to N. 20° W., across the general trend of schistosity in altered felsite, and north to N. 20° E. in altered greenstone. They are well exposed in the American Eagle adit, where they range in width from a few inches to about 5 feet, and occur in sericite schist at or near contacts.

Near the surface some of the shear zones are marked by copper stains, iron oxide, and barite, and the important sulphide deposits are restricted to these zones.

ORE DEPOSITS

Mineralized Zones and Ore Bodies

Those portions of the shear zones that contain appreciable stringers and disseminations of sulphides other than pyrite are termed mineral-

[6] Plunge, as here used, is defined as the vertical angle between a horizontal plane and the line of maximum elongation.

ized zones. The single shear zone in the Blue Moon mine contains two mineralized zones, in which occur three ore bodies; another mineralized zone is located a short distance west of the Blue Moon mine. Economic deposits have not been discovered in the other mineralized zones in the area, but several places are believed to merit further exploration. The known ore bodies are narrow lenses that pitch nearly down the dip.

Minerals of the Primary Ore. Sulphide minerals visible in the deposits are, in order of abundance: dark-brown sphalerite, pyrite, tetrahedrite, galena, and chalcopyrite. Some sphalerite occurs in massive aggregates as much as one inch in diameter, but most of it is in lens-shaped grains. Pyrite occurs as small cubes and pyritohedrons, as thin massive stringers, and as films on schistosity planes. Tetrahedrite occurs as small granules at the ends of sphalerite lenses and as tiny veinlets in sphalerite. Galena is rare in the upper part of the Blue Moon mine but more abundant at depth and in other mineralized zones. Chalcopyrite was seen only in the more massive pyrite.

Other minerals in the ore are sericite, clear quartz, barite, calcite, and milky quartz. The sericite is in minutely crinkled or smooth folia, parallel to the schistosity of the enclosing rock. The other minerals occur as veinlets or layers along schistosity planes. Sericitic gangue makes up at least 25 percent by volume of the most massive ore.

Texture and Structure of the Ore. The sulphide deposits are parallel to schistosity in the adjoining sericite schist, as shown by the map of the 165 level, Blue Moon mine (pl. 55). Ore occurs as layers ranging in thickness from a fraction of an inch to several feet, and with decrease in the amount of sulphides and barite grades into sericite schist.

The layers of sulphides and gangue give much of the ore at the Blue Moon mine a gneissic appearance. Stringers and lenticular grains of sphalerite, oriented parallel to schistosity, occur in sulphide-rich layers less than half an inch thick. Tetrahedrite granules occur at the ends of sphalerite grains, and in some places pyrite and quartz form aggregates at the tails of sphalerite lenses. The ore has an augenlike structure, due mainly to the shape and distribution of sphalerite grains.

Results of Oxidation and Enrichment. Complete oxidation of sulphides has extended downward 40 to 70 feet but along fault zones incomplete oxidation has extended deeper. The leached outcrop of the ore is a fissile, generally crumpled sericite schist that contains barite and sparse porous yellow-brown iron oxide, and locally is stained by copper carbonates. Red stains and cubes of iron oxide, which are scattered throughout the weathered altered rock, are apparently derived from pyrite and do not indicate zinc-copper mineralization.

Stringers of azurite and malachite occur in the oxidized part of the mineralized zones and a small amount of chalcocite occurs in the upper 10 to 30 feet of the sulphide zone. No supergene zinc minerals have been recognized.

Geologic History of the Deposits

Excluding surficial alteration, the geologic events that relate to the deposits are summarized as follows:

1. Regional deformation of the rocks, accompanied by low-grade metamorphism and development of schistosity. Shearing along part of the chlorite schist-felsite contact.
2. Entrance of hydrothermal solutions along and near the sheared contact, altering parts of the volcanic and intrusive rocks.

3. Shearing in narrow zones within and near altered rock, especially near contacts between rocks of different competency. Probably in part concomitant with entrance of solutions.
4. Mineralization: formation by hydrothermal solutions of the important sulphide deposits along shear zones, accompanied in places by rock alteration and shearing.
5. Deformation of the deposits by strike faults.

At the time they were invaded by hydrothermal solutions the rocks were probably still affected by the forces that caused regional deformation, because some of the altered rocks have been intensely crumpled and contorted, as described above. As the rocks were being altered, sericite accentuated the schistosity and shearing produced crinkles and small folds in the sericitized rocks.

Most of the alteration probably occurred before the formation of abundant sulphides, for some of the deposits occur in shear zones that apparently deform altered rocks.

The sulphides replaced the sericite, probably in this order: pyrite, followed by sphalerite associated with barite, then tetrahedrite and other sulphides, and lastly more pyrite. The films of slickensided pyrite on schistosity planes and the lenticular sphalerite grains with tetrahedrite tips suggest a renewal or continuation of shearing during ore deposition, but do not necessarily indicate metamorphism of the ore.

Continuation of deformation after the formation of sulphides is shown by faulting and brecciation of the ore at the Blue Moon mine.

Areas Favorable for Exploration

At the Blue Moon property the character of the primary ore is essentially constant through a known vertical range of nearly 600 feet. There is therefore reason to believe that ore may occur at greater depth. Since mineralized areas west of the Blue Moon mine apex below the surface, it is possible that other ore deposits not exposed at the surface may occur in shear zones in fissile sericite schist.

Drill logs show that along contacts between rocks of different competency shear zones and sericite schist may exist at depth although neither crops out. Geologic contacts, where sheared sericite schist might reasonably be inferred at depth, are thus favorable for exploration. Several such places are discussed in the sections on individual properties.

The regional dip of schistosity and other structural features is eastward, but local west dips are common. Indeed, at the Blue Moon mine all the rocks, including ore bodies, dip westward. This anomalous westward dip may be one reason for apparent localization of ore at the Blue Moon; elsewhere in the Foothill belt, however, ore commonly occurs in rocks with a normal eastward dip.

A brief reconnaissance of the regions immediately north and south of the area failed to disclose other alteration zones near which sulphide deposits may occur. These regions, therefore, are not regarded as favorable for finding new deposits. It is possible, however, that geophysical prospecting along the contact between chlorite schist and felsite will disclose other altered, possibly mineralized zones that are not exposed.

AMERICAN EAGLE PROSPECT

The American Eagle prospect includes the American Eagle, Blue Bell, and Bonanza claims, and is approximately the part of the area south of coordinate N 89.500 on plate 50. The surface is prospected by about 50 shallow pits, trenches, and shafts, most of which were dug during the 1890's in search of gold; in 1899 an appreciable quantity of gold was produced. At about this time the American Eagle adit was driven from the west into the main alteration zone. In 1942 a small block of ground above the adit was stoped and a winze deepened by J. H. A. Williams of New York.

Deposits Near the American Eagle Adit

Development and Exploration. The American Eagle adit consists of about 750 feet of horizontal workings. shown in plan on plate 52. Two winzes are sunk below adit level; one is 40 feet deep but the other is filled. Immediately north of the 40-foot winze is a nearly vertical 100-foot raise to the surface and near the north end of the drift is a caved raise. South of the winze is a short stope about 25 feet high.

The ground below and north of the adit is explored to a depth of 300 feet below the surface by seven Bureau of Mines drill holes totaling 2.800 feet. These holes are shown in plan on plate 52; cross-sections through hole 1 (section D-D′, pl. 53) and hole 7 (section 4-4′, pl. 51) are also shown.

Geology. Most of the adit traverses silicified. sericitized felsite tuff and breccia, but at the east end of the workings unaltered felsite and two narrow greenstone dikes are exposed. Several bodies of quartz-pyrite rock occur in the altered felsite and the largest of them may continue through to the surface.

In the adit the average trend of schistosity is about north, although near the contact between silicified and sericitized felsite the strike in places is west of north. Locally, and especially near this contact, the rocks are extremely fissile, and the schistosity has been crinkled and folded: crinkles in schistosity plunge steeply southward; minor folds in schistosity plunge 50°–70°, toward either the north or the south. These features strongly suggest that the contact between silicified and sericitized felsite is a zone of shearing, and it is along or near this contact that sulphides have been introduced to form the mineralized zones.

Mineralized Zones. The drill holes intersect six mineralized zones, designated "a" to "f" on plates 52 and 53. With one exception, zone "f", they are arranged in overlapping en echelon bodies, each mass lying west of its southern neighbor. Two zones, "a" and "b", are exposed in the adit, but the other zones lie east or north of the workings.

At the adit level most of the sulphides have been oxidized and the mineralized zones consist of stringers, knots, and lenses of azurite and barite in sericite schist stained with malachite and limonite. Generally azurite lenses are less than half an inch long and are restricted to zones not over 6 inches thick, but malachite stains may be spread over a width of 5 feet.

At the head of the filled winze, a zone 1 to 4 inches thick contains sphalerite, pyrite, and barite, with azurite and malachite. Unoxidized pyrite is locally abundant in the more massive silicified felsite.

Mineralized zone "a" is exposed in the workings intermittently over a length of 140 feet, and is intersected by drill holes 1 and 7. This zone was not encountered by hole 4 and hence the north boundary lies somewhere south of the hole and the zone probably plunges steeply to the south, parallel to the crinkles in schistosity.

Of the six mineralized zones, zone "a" alone approaches economic grade. At the time of the writers' examination the bottom of the 40-foot winze was not accessible, but G. R. Heyl[7] reports ". . . . an irregular vein about 4 feet wide of partially oxidized sulphides . . . . Sixteen cut samples have been taken on the bottom and sides of this winze, which according to Mr. Williams, assayed as follows: copper, from 1.53 to 11.01 percent; zinc, from 2.59 to 8.29 percent; lead, from 0.71 to 1.02 percent; gold, from 0.01 to 0.22 ounces to the ton; and silver, from 0.99 to 2.58 ounces to the ton." Comparison of these assays with the assays of core samples suggests that in each case the lesser figure may be more typical of the average ore, although the high copper content may be due to chalcocite.

Mineralized zone "b" is exposed near the southeast part of the workings, and is intersected by holes 1 and 7. This zone is very low-grade.

Future Exploration

No economic zinc deposits have been indicated in the six mineralized zones near the American Eagle adit, but this fact does not preclude the possibility of finding ore bodies in that region. However, ore bodies probably do not occur within 300 feet of the surface. The most favorable area to explore appears to be the downward extension of mineralized zone "a."

Aside from the sulphide-bearing zones known to exist, four other areas may contain ore bodies. They are listed in order of merit.

1. The sericite schist mass near coordinates N87,500, E90,800 (pl. 50). Yellow-brown gossan within the schist indicates the probable presence of copper (and, therefore, possibly zinc) at depth (pl. 51, section 5-5′). A narrow vein of hematitic jasper may indicate faulting along the contact between schist and felsite at this point. The gossan is exposed in a single pit and further trenching is needed to warrant evaluation.
2. The contact between silicified chlorite schist and silicified felsite near coordinates N89,350, E90,450 (pl. 50). Sericite schist and quartz veins are exposed along the contact in this region. Drill hole 1 of Red Cloud Mines, Inc., explores the silicified chlorite schist but fails to reach the chlorite schist-felsite contact by 100 feet. The hole did intersect a zone of numerous thin quartz-sulphide veins but assays indicate the rock as a whole contains less than 0.5 percent of either zinc or copper.
3. The sericite schist mass near coordinates N86,900, E90,900 (pl. 50).
4. The west margin of the greenstone dike near coordinates N87,750, E91,150 (pl. 50). Sericite schist is exposed along part of this contact.

BLUE MOON MINE

General Statement

The Blue Moon mine lies within the Porcupine, Porcupine Fraction, and Blue Moon group of claims, which covers approximately that part of plate 50 north of coordinate N89,500.

According to J. H. A. Williams[8] the outcrops of the ore deposits were first prospected in the early 1930's. In 1935 a small amount of gold-silver-copper ore was mined from the oxidized material. Beginning in 1940 Red Cloud Mines, Inc., explored the area with shallow underground workings that disclosed the zinc ore. Subsequently the company put down 11 drill holes totaling 5,000 feet which indicated two regions containing economic zinc deposits: 1) the two mineralized zones developed by mine workings, and 2) the margins of the northern prong of the main alteration zone, here called the west silicified zone (pl. 56).

[7] Heyl, George R., personal communication.
[8] Personal communication.

In 1943 Red Cloud Mines, Inc., was acquired by the Hecla Mining Co. of Wallace, Idaho. The mine was equipped to handle 200 tons per day and stoping began late that year. Up to October 1, 1945, more than 50,000 tons of ore had been produced, averaging about 14 percent zinc and containing a little lead, copper, silver, and gold. Production is given in table 1. Cut-off grade was about 7 percent zinc and minimum stope width 4 feet.

Table 1. Production of the Blue Moon mine.[1]

Period	Ore (tons)	Copper[2] (pounds)	Zinc[2] (pounds)	Lead[2] (pounds)	Gold (fine ounces)	Silver (fine ounces)
1944	34,267	186,902	6,775,080	291,656	1,893	113,573
1945	21,389	219,136	6,912,840	242,097	1,553	95,392
Totals	55,656	406,038	13,687,920	533,753	3,446	208,965

[1] Minerals Yearbook, U. S. Bur. Mines 1944-1945.
[2] Pounds of metal contained in concentrates.

The ore was concentrated at the flotation mill of the Jenny Lind gold mine, 4 miles from the Blue Moon mine.

Zinc concentrates were sold to the Metals Reserve Co. and delivered by truck to the railroad at Merced Falls and, after August 1945, at Merced. Copper-lead concentrates were trucked to the American Smelting and Refining Co. lead smelter at Selby, California.

In November 1945 the mine was abandoned because of caving.

Development

By October 1, 1945, the Blue Moon deposits had been developed along the strike for 320 feet and to a depth of 490 feet below the outcrop. No. 1 shaft was 35 feet deep and was connected to deeper workings by a winze. No. 2 shaft, used for hoisting, extended 500 feet along an incline of 80° to the west. Levels were turned off at 125, 165, 275, 385, and 450 feet, and a crosscut driven through the ore at 500 feet. The workings, which extended only slightly beyond known ore bodies, totaled 2,370 feet, of which 1,430 was drifts and crosscuts and 940 was shafts and raises. Plates 54 and 58 show respectively a plan and vertical projection of these workings.

The ground west and north of these workings is explored by three drill holes to a depth of 620 feet below the outcrop.

Deposits Developed by Mine Workings

The developed ore deposits occur as two tabular zones of mineralized sericite schist enclosed in felsite breccia; most of the felsite is the typical schistose variety, but some of it is massive. Thin dikes of massive greenstone occur along both walls of the schist unit. The relations of the two mineralized zones to the country rock are shown by geologic level maps on plate 55, and by sections on plates 51, 56, and 57.

The fissile sericite schist contains abundant disseminated pyrite, and assays indicate that rock mapped as "low-grade schistose ore" contains at least 2 percent zinc. The schist grades laterally into felsite breccia through a zone 1 to 3 feet thick. Near the north end of the 165 level is a schistose greenstone dike that locally contains sericite and pyrite.

Along this dike and in the sericite schist at No. 1 shaft collar, the schistosity is thrown into closed folds that plunge 80° to 85° northward, parallel to minute crinkles and to the ore shoots and mineralized zones. Schistosity in the felsite breccia strikes N. 5°-20° E., as elsewhere in the area, but dips westward. The mineralized zones strike a few degrees more westerly than the felsite schistosity and dip steeply westward. This cross-cutting relationship, together with the extreme fissility of the schist and the minor folds and crinkles in schistosity, indicates that the deposits occur along a shear zone.

From a point about 70 feet north of No. 2 shaft collar this shear zone can be traced southward at the surface to a point about 70 feet south of No. 1 shaft collar. Within this 400-foot distance are the two mineralized zones; the north zone crops out near No. 2 shaft and the south zone near No. 1 shaft. Beyond these limits the shearing fades out, suggesting that the mineralized zones extend only slightly beyond the workings.

Three elongate, steeply pitching ore shoots comprise the greater part of the mineralized zones. The apparent ratio between average width, stope length, and pitch length of these ore bodies is about 1:10:30. Although the maximum size of the ore bodies is not fully known, the largest, No. 1 ore body, probably contained at least 60,000 tons before stoping. Outlines of the ore shoots are shown on plate 58.

Sulphides in the deposits have been completely oxidized to a depth of 40 feet and partly oxidized to a depth of 80 feet.

Primary Ore. Below the oxidized zone the ore is banded or massive and consists of dark-brown sphalerite, pyrite, and small amounts of tetrahedrite, galena, and chalcopyrite, in a gangue of sericite, barite, clear quartz, and calcite. Calculations from milling data suggest that the sphalerite may contain as much as 7 percent combined iron; but it probably contains less. The gneissic appearance of most of the ore is due to thin sphalerite-rich layers and lenticular sphalerite grains. Massive, siliceous pyritic ore occurs along part of the footwall of the north mineralized zone; a second type of massive ore consists chiefly of sphalerite and barite.

Calculations from assay data indicate that the ore contains slightly more than 1 ounce per ton of silver for each 0.1 percent copper, and presumably much of the silver occurs in tetrahedrite. The ore contains only small amounts of gold.

Post-ore Deformation. The ore deposits have been considerably deformed by strike faulting. A fault zone along the hanging wall of the deposits is composed of closely spaced slip-planes that strike N. 5° E. to N. 15° W., parallel to the ore and fault zone as a whole, but dip more gently, 40°-72°, westward. Drag folds in schistosity indicate reverse movement along the slip-planes. The southern part of the fault zone ranges in width from a few inches to as much as six feet.

In the northern workings, where the fault zone trends N. 15° W., the slip-planes pass into a pod of breccia with a maximum strike length of 120 feet and a maximum width of 52 feet. Similar breccia is intersected 620 feet below the surface (or nearly 600 feet below the bottom of the oxidized zone) by drill hole 8. The breccia, which in places completely cuts out the ore, reached the surface, but is now covered by the waste dump of No. 2 shaft.

Fragments in the breccia range in diameter from a fraction of an inch to 4 feet and include felsite volcanic breccia, greenstone, sericite schist, and ore, each type adjacent to similar rock in place. Abundant ore fragments occur in the eastern 15 feet of breccia but this material has not been mined. Because many tabular fragments are subhorizontal the breccia is crudely stratified and has a startling resemblance to stope fill. The breccia matrix is claylike and contains a few quartz-chlorite veins.

A fault along part of the footwall of the north mineralized zone—fault "a" on maps and sections—merges southward and downward with the hanging-wall fault zone. The fault dips 48° to 85° westward, generally about 15° flatter than the ore shoots. Although in section B-B′, plate 57, the fault appears to cut off the ore, the slip-plane actually is parallel to the margin of the mineralized zone, and, in places, parallel to the margin of ore. Ore bodies and rock units are not offset along the fault, and displacement, therefore, must be very slight.

The same reasoning applies to the hanging-wall fault breccia. Displacement must be negligible, for despite the thick breccia the horizontal length of the fault zone is not over 400 feet and no rock units are offset, although locally the ore is brecciated and the minable width decreased. The known faults are restricted to the margins of the mineralized zones; therefore similar post-ore faults, if found, may be guides to other ore deposits.

During the summer of 1945 the hanging-wall fault breccia caved above the 275 level, blocking that level south of the shaft, and in order to continue mining a drift was run southward in the footwall. At the same time the fault breccia also caved above the 165 level, destroying all ore above that level in No. 1 and No. 2 ore bodies. About 60 feet south of No. 2 shaft a hole appeared, 15 feet in diameter at the surface but widening abruptly downward; breccia was exposed over the entire width.

In November 1945 the fault breccia caved again, resulting in abandonment of the mine. The amount and location of ore destroyed at that time are unknown.

North Mineralized Zone. The north mineralized zone is explored from the surface to the 500 level, but only the south boundary of the zone is exposed. The zone is probably lenticular, as suggested on plate 58. It has a developed horizontal length of 220 feet and a maximum width of 38 feet. The over-all trend of the zone is N. 15° W., but in the lower workings the strike is nearly north. Although in the south part of the lower workings, along fault "a," the dip is as low as 48°, elsewhere the dip is 75° to 87° westward.

No. 1 ore body, at the hanging wall of the north mineralized zone, extends from the lower limit of oxidation downward at least to the 500 level, and as outlined on plate 58, may extend deeper. According to J. H. A. Williams[9] abundant gossan cropped out along the north mineralized zone; this fact suggests that No. 1 ore body reached the present surface. The maximum stope length is 180 feet, on the 275 level, and the maximum width is 28 feet, between the 450 and 385 levels. Post-ore brecciation has

[9] Personal communication.

reduced the width of ore of economic grade and at one place on the 165 level and at the south end of the 450 level the ore is destroyed.

No. 2 ore body, at the footwall of the north zone, is exposed in cross-cuts but has not been developed. The ore body probably pinches out not far above and below the 165 level. The strike length is not over 80 feet and the width is about 5 feet.

South Mineralized Zone. The south mineralized zone, developed from the surface to the 165 level, is along the strike projection of the north zone. The two zones are 100 feet apart at the surface but converge downward. The south zone, which strikes N. 5° E. and dips 80° westward, has a maximum strike length of 100 feet and a width ranging from a few inches to about 12 feet. At the surface the sericite schist of the south zone is not more than 2 feet wide and is about 150 feet east of the main alteration zone.

No. 3 ore body comprises most of the explored part of the south mineralized zone. It ranges in stope length from 50 to 80 feet and in width from 4 to 9 feet. Along the strike sulphides and sericite schist pinch out at almost the same points. The ore shoot doubtless extends well below the 165 level.

Relation of Strike to Width of Ore. Where the ore bodies and post-ore faults trend most westerly the ore is widest and post-ore brecciation has occurred. If, during pre-ore movement, the west or hanging wall of the mineralized zones moved upward and southward with respect to the footwall, then along the westward trending parts pressure would be relieved and open spaces developed, which might favor formation of a wide ore body. Conversely, where the trend is north, pressure would be greatest and the ore body narrow. Although no direct evidence exists for this pre-ore faulting, the association of the thicker parts of the ore body with westerly strikes suggests such movement.

If post-ore deformation followed the same pattern, brecciation could occur along the westward trending parts, but along those parts that trend northward, movement might be restricted to shearing.

Grade of Ore. Data furnished by Red Cloud Mines, Inc., indicate that during the period February-July 1944 the mill heads averaged 12.6 percent zinc, 0.36 percent copper, and about 0.3 percent lead, but from July to October they averaged more than 14 percent zinc. In 1945 mill heads averaged about 15 percent zinc, 0.4 percent copper, and 0.5 percent lead.

Engineers for Red Cloud Mines, Inc., and other companies, cut 71 samples in the three ore bodies at the 165 level. The weighted average of these samples is 14.7 percent zinc, 0.47 percent copper, a trace of lead, 5.1 ounces of silver to the ton and 0.08 ounce of gold to the ton. Apparently the deeper parts of No. 1 ore body contained more lead and this explains the difference between mill heads and cut samples. Production figures show that the average ratio of copper to lead to zinc, for the entire mine, is about 2 to 3 to 80. The average of 35 samples cut in low-grade schistose ore of the north mineralized zones is 5.9 percent zinc. Core samples and cut samples contain from 1.5 to 24.8 percent zinc over widths ranging from 2 to 7 feet.

Deposits in the West Silicified Zone

The west silicified zone is a prong of the main alteration zone that crops out along a hornblende felsite porphyry dike 160 feet due west of No. 1 shaft. Although at the surface there is no indication of zinc-lead-copper sulphides, at depth the zone contains ore deposits (plate 51). This zone is 10 to 70 feet wide, trends nearly north, and dips steeply westward. Schistosity in the zone dips steeply, either to the east or to the west. The north limit of the dike plunges steeply southward, and along the dike margin schistosity locally is thrown into closed folds that plunge southward about 70°.

The west silicified zone is explored on the 165 level, and five drill holes partly outline mineralized zones at each margin.

At the east margin, low-grade schistose ore is intersected by the 165 level and hole 6, and economic zinc ore in sericite schist is encountered by holes 7 and 8 about 500 feet below the surface. Drill logs suggest that the ore is similar to the deposits mined but contains less sphalerite and more galena. Two alternate interpretations of the inclination of drill hole 7 are shown on section 1-1. plate 51, but the surface geology and drill-hole information can best be correlated with the steeper inclination (7b). Barren hole 5 suggests that the ore occurs in two shoots which, if parallel to folds in schistosity, plunge steeply southward (A and C, vertical projection, pl. 51).

At the west margin, low-grade schistose ore is intersected by hole 4 about 135 feet below the surface (B, vertical projection, pl. 51 and pl. 57). Hole 8 did not intersect sulphides at the west margin directly down dip from hole 4, but this deposit also may plunge southward.

Future Exploration

The north and south mineralized zones and the margins of the west silicified zone are the only areas in the immediate vicinity of the Blue Moon mine known to be mineralized.

The parts of the west silicified zone most likely to contain ore bodies are outlined on plate 51. Dimensions shown are derived by assuming a similar ratio between width, stope length, and pitch length for these postulated deposits as for known ore bodies.

As suggested on plate 58, the north limit of sulphides in the north mineralized zone may pitch northward. Should this prove to be correct, a considerable area north of the workings would be favorable for exploration, for it might contain a hitherto undiscovered ore body. The narrow band of ore exposed in the northern drift face on the 385 level may widen northward, and merits exploration to determine its northernmost extent. Drill holes 6 and 7, intended to explore this region, probably end short of the mineralized zone (sections 1-1′ and 3-3′, pl. 51).

The fault breccia intersected 620 feet below the surface in hole 8 (section 2-2′, pl. 51) lies on the pitch projection of the south mineralized zone and No. 3 ore body. Although ore is destroyed at the intersection, this condition is possibly local, as it is in the workings, and the mineralized zone above or below the intersection may contain nonbrecciated ore. The presence of brecciated ore in this region need not discourage deeper exploration of both mineralized zones.

Outlook

Substantial tonnages of ore averaging about 14 percent zinc still remained in or adjacent to the developed part of the deposits after abandonment of the mine in November 1945. Most of this ore is in the No. 1 ore body. The ore in No. 2 ore body above the 165 level was destroyed by caving, but some ore exists below that level. The No. 3 ore body also continues below the 165 level, but has been mined out above the level. Some low-grade schistose ore carrying about 6 percent zinc was also present in the north mineralized zone. The size of the ore bodies in the west silicified zone is unknown, but possible dimensions and shapes are inferred on plate 51; some of this ore averages about 10 percent zinc.

THE JESSE BELLE COPPER MINE, MADERA COUNTY, CALIFORNIA *

By Manning W. Cox ** and Donald G. Wyant **

OUTLINE OF REPORT

ILLUSTRATIONS

ABSTRACT

The Jesse Belle copper mine, near Madera, Madera County, California, has produced small quantities of ore intermittently since about 1870.

The area near the mine is underlain by quartz-mica schist and gneiss, and quartz diorite. Foliation in the metamorphic rocks strikes N. 20°-25° W. and dips steeply eastward. Many narrow shear zones occur in the schists.

Ore deposits of the area are narrow, lenticular, chalcopyrite-quartz veins containing cobaltite. The average grade of the ore may be 3 percent copper and 0.1 to 0.3 percent cobalt. The deposits are localized at intersections of shear zones in the schist. Exploration has shown that the vein zones persist to at least 300 feet vertically below the surface, but individual veins are seldom more than 40 feet in longest dimension. Ore shoots, composed of many veins, are not over 45 feet in stope length but are as much as eight times as long in pitch length. The ore shoots probably continue down pitch, but may increase in iron content with depth. Mineralization in the area may be limited downward by granodioritic rocks, perhaps at as shallow a depth as 1,000 feet below the surface.

INTRODUCTION

The Jesse Belle mine is in the Foothill copper-zinc belt on the western slope of the Sierra Nevada (pl. 1). The property is 15 miles northeast of the city of Madera, in Madera County, California, in sections 18 and 19, T. 9 S., R. 19 E., and section 13, T. 9 S., R. 18 E., Mount Diablo base and meridian. Ownership is divided between the Daulton estate, which controls the southern part, and M. R. Buchaneau of Madera, who controls the northern part.

The mine is in low grass-covered hills about 600 feet above sea level. There are no permanent streams nearby but water for mining needs can be obtained from a well on the Buchaneau ranch.

* Published by permission of the Director, Geological Survey, U. S. Department of the Interior. Manuscript submitted for publication May 19, 1948.

** Geologist, Geological Survey, U. S. Department of the Interior.

A dirt road from the Madera-Raymond highway leads 1½ miles north to the mine. A spur line of the Southern Pacific Railroad to the Daulton ranch, 3½ miles southwest of the mine, can be used to ship ore.

Cobalt was first noted in the ores of the Jesse Belle mine during a preliminary examination by R. S. Cannon, Jr. and G. R. Heyl of the U. S. Geological Survey as part of a wartime investigation of the Foothill copper-zinc belt. M. W. Cox and D. G. Wyant mapped the accessible underground workings and the surrounding surface area during April 1944. Mr. Warren Sisson kindly allowed use of an assay map of the Jesse Belle workings made in April 1943 by W. M. Hoff. Information concerning the ore shoots of the north part of the 100 level and the entire 300 level has been taken from Hoff's map, as these workings were under water at the time of this study.

HISTORY AND PRODUCTION

The property was discovered before 1870 but no record of its early history is known to the writers. The Jesse Belle shaft was reconditioned in 1937 by a company which built a small mill on the property. Both mill and shaft burned and the property was abandoned.

Mr. J. E. Sisson leased the property and with the aid of an RFC loan, reopened and sampled the Jesse Belle shaft and adjacent workings between November 1942 and April 1943. In January of 1944, with a second RFC loan, stopes were prepared on the 200 level. The mine was operated until approximately May 15, 1944 and about 40 tons of sorted ore was shipped.

The size of the stopes in the accessible workings indicates that total production was less than 1,000 tons of ore which may have contained 3 percent copper.

GEOLOGIC RELATIONS

The Jesse Belle area is 22 miles south of the southern end of the Mother Lode at Mormon Bar. A large body of granodioritic rock extending westward from the main Sierra Nevada intrusives crops out one mile east and south of the mine. Most of the rocks of the surrounding area are schist and gneiss of medium-rank metamorphism. The schist of the Jesse Belle area possibly can be correlated with slightly metamorphosed sedimentary rocks of the Mariposa and Amador units[1] that are exposed in the Indian Gulch quadrangle 12 miles to the north. Three miles west of the mine the metamorphic rocks are overlapped by Tertiary sediments of the San Joaquin Valley.

The area near the mine (pl. 59) is underlain by quartz-mica schist and gneiss, intruded by a stock of quartz diorite. The metamorphic rocks strike northwest and dip steeply eastward. Shear zones in the metamorphic rocks strike in two directions (see below) and contain chalcopyrite-quartz veins.

Quartz-biotite schist, derived from shale, sandstone, and conglomerate, is the most abundant rock in the area. Bedding in the schist can be recognized as a quartz-rich and quartz-poor layering, generally parallel to the schistosity. Some of the beds are metaconglomerates; others are

[1] Taliaferro, N. L., Manganese deposits of the Sierra Nevada, their genesis and metamorphism: California Div. Mines. Bull. 125, p. 283, 1943.

metasandstones that show cross-bedding. The schistosity strikes N. 20°-25° W. and dips more than 80° to the east. Along the west side of the area (pl. 59) small attenuated folds in bedding plunge steeply northwestward. At the apices of the folds clots of feldspar and quartz resemble granite (fig. 1).

Near the Jesse Belle shaft dikes of quartz-muscovite gneiss cut across the schistosity of the schist. Schistosity within the dikes is parallel to the dike walls and may diverge as much as 30° from the schistosity of the country rock. The gneiss was probably derived from a felsite. The sinuous pattern of the dikes (pl. 59) suggests folding in which the west margin of the dikes moved northward with respect to the east margin.

North of the Rosati shaft a small stock of massive porphyritic quartz diorite is exposed. Aplitic apophyses extend from the stock along the schistosity of the schist. Near the quartz diorite the schist contains clots of feldspars and stringers of quartz-feldspar rock. This area is shown on the surface map (pl. 59) as feldspar-biotite schist.

Massive quartz without metallic minerals is present, and occurs in lenses along the eastern margin of the area that trend N. 45°-60° W. and dip steeply eastward across the foliation of the schist. The relation of these lenses to the ore veins was not determined.

Two persistent sets of flat joints in the area trend N. 45°-60° W. and N. 55°-70° E., and in general dip less than 15°. These joints are offset along shear zones. Near the mineralized areas sulphide-quartz veinlets as much as 3 inches thick fill some of the joints.

A set of closely spaced joints or fracture cleavage that trends N. 70° E. and dips nearly vertical occurs in all the rocks of the area.

Shear zones dipping steeply eastward trend in two directions: N. 10°-25° W. and N. 45°-60° W. Along the walls and at the ends of the shear zones are vertical quartz-coated feather joints which strike due north to N. 10° E. The feather joints, and the slickensides on the fault surfaces, suggest that the west side of the northward trending shear zones has moved nearly horizontally northward with respect to the east side. Offsets of the gneissic dike and of joints in the mine workings suggest that the displacement along the shear zones has been at most 50 feet and may be much less. The westward trending shear zones link the more northerly ones.

The presence of small stocks of quartz diorite and the proximity of the area to the main Sierra Nevada intrusives suggest that granodioritic rocks may underlie the area at shallow depth, on the order of 1,000 feet. The shear zones and veins appear not to extend into the massive intrusive rocks south or north of the mine area. If an analogous relationship exists in underlying intrusive rocks the downward extent of the veins is limited.

ORE DEPOSITS

General Features

The ore deposits of the Jesse Belle area are groups of chalcopyrite-quartz veins in and adjacent to shear zones. Eleven mineralized shear zones, here termed vein zones, are known in the area. A typical zone is sketched in figure 2.

The veins consist of chalcopyrite, pyrite, pyrrhotite, and cobaltite, in a gangue of quartz, biotite, muscovite, feldspar, graphite, and a little

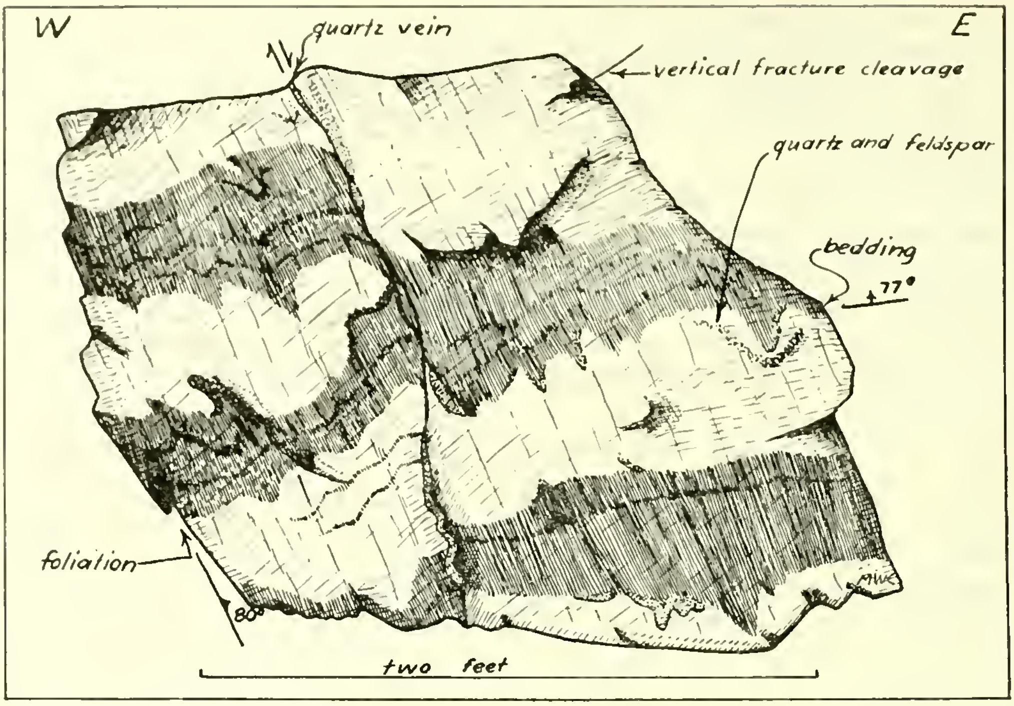

FIG. 1. Sketch of horizontal outcrop at west margin of Jesse Belle mine, Madera County, by M. W. Cox and D. G. Wyant.

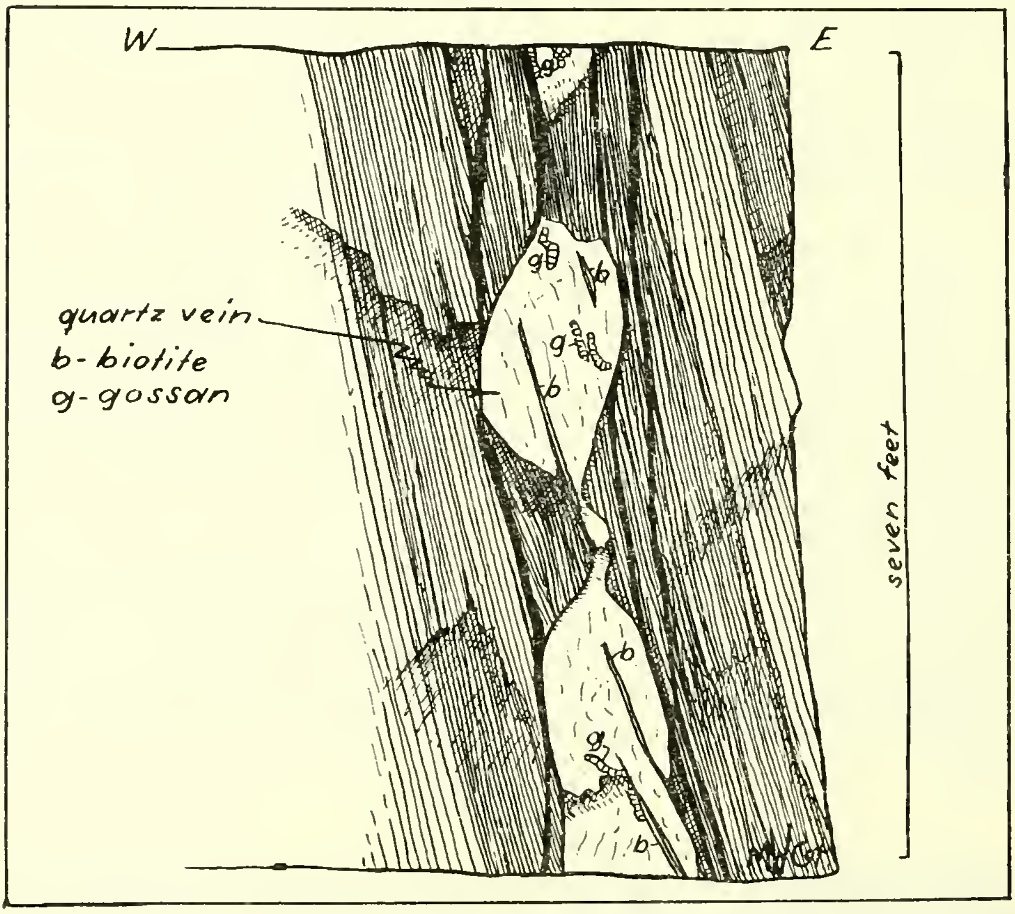

FIG. 2. Sketch of north wall of pit on Rosati vein zone.

epidote. Quartz comprises from 10 to 90 percent of the veins; the average content is near 70 percent. Those veins that carry the most sulphides contain the least silicates. Although sulphides and graphite occur in the same veins, the highest-grade veins have no graphite. Sulphide-bearing quartz pods 1,000 feet north of the area shown on plate 59 contain biotite and feldspar aggregates 12 inches in length.

Metallic minerals make up from 1 to 80 percent of the veins; the average content is estimated at 5 percent. At least 75 percent of the metallic mineral content is chalcopyrite; pyrite makes up from 10 to 25 percent; pyrrhotite and cobaltite are rare. Chalcopyrite and pyrite occur together in fine-grained aggregates in which individual crystals are difficult to recognize. Cobaltite is intergrown with the sulphides in cubes and pyritohedrons, some of which are cut by chalcopyrite veinlets.

In the other sulphide deposits of the region, such as the Buchanan and Daulton mines, pyrrhotite is the most abundant sulphide. It is possible, therefore, that at greater depths pyrrhotite may be more abundant in the Jesse Belle deposits. If so, the iron content of the ore will increase with depth and the copper content may decrease.

Inclusions of schist locally give the veins a banded appearance but the vein minerals do not form layers parallel to the vein walls. The metallic minerals are intergrown with quartz but also occur along fractures in it. A few small druses of quartz and pyrite occur in earlier quartz. The other minerals are intergrown with quartz to form a massive aggregate. Silicified masses and small white feldspars are developed in the wallrocks in places but generally there is little perceptible wallrock alteration.

Exploration has shown that the vein zones persist a minimum of 300 feet vertically, but individual veins rarely exceed 40 feet in either pitch length or strike length. The veins range in width from a fraction of an inch to 29 inches. Vein zones are from a few inches to 4 feet wide, but veinlets extend into the walls of the shear zones as far as 8 feet. The veins do not disturb the foliation of the schist except where veinlets occur in flat, crosscutting joints.

Most veins are localized near the intersection of two or more shear zones. Where the veins contain appreciable sulphides ore shoots are formed which follow the intersection of the shear zones, or the intersection of a shear zone with foliation of the schist. The shoots generally plunge [2] more than 75° northward. They are at least 8 times as long down the pitch as they are along the strike.

The Jesse Belle deposits were formed by replacement of sheared schists by quartz, silicates, and sulphides. They are therefore younger than the metamorphism and do not represent metamorphosed ore deposits.

Jesse Belle Shaft Zones

Four vein zones near the Jesse Belle shaft can be traced for an aggregate distance of 480 feet along the surface. Approximately 70 feet of these outcrops contain more than 5 percent gossan. The four zones are explored by numerous pits and by four shafts, two of which are caved. The principal mine entry is the Jesse Belle shaft which extends 300 feet along an incline of 85° to the east. Drifts, shown in plates 60 and 61, are

[2] Plunge, as here used, is defined as the vertical angle between a horizontal plane and the line of maximum elongation.

run north from the shaft at 100 and 200 feet and both north and south at 300 feet. The south shaft is 45 feet deep and connects to a small open stope.

Three ore shoots are developed; two of them extend northward from the Jesse Belle shaft, and a third is opened at the south shaft. The two shoots of the Jesse Belle shaft are along two shear zones which intersect near the shaft and diverge northward. The Jesse Belle shaft is sunk along the western shear zone. The footwall ore shoot occurs along this zone and in the adjacent schist. On the 200 level sulphide-bearing quartz stringers make up as much as 10 percent of the rock; the copper content is estimated at 2 percent. The footwall or western zone is not explored on the 100 level.

At the intersection of the two shear zones and along the eastern zone chalcopyrite-quartz veins form the hanging-wall ore shoot. On the 100 level there are only short veinlets along the hanging-wall ore zone. On the 200 level the shoot consists of only one vein ranging from 1 to 29 inches in width and containing about 15 percent sulphides. The intersection of the two shear zones plunges northward about 80°, and the ore on the 300 level, shown by Hoff's map, is just north of the downward projection of this intersection.

The ore shoot developed by the south shaft plunges, at the base of the shaft, 78° to the north. The ore shown by Hoff's map on the south 300 level lies on the downward projection of this ore shoot.

A third mineralized zone, shown on Hoff's map 150 feet north of the Jesse Belle shaft on the 100 level, was not examined as the level was under water there.

A weighted average of the Hoff samples gives 3.9 percent copper. Forty tons of sorted ore from the 200 level stope shipped in March 1944 carried 4.12 percent copper and 0.59 percent cobalt (pulp sample assayed by the U. S. Geological Survey). A grab sample of sorted ore from the ore bin (taken by the writers and assayed by Abbot A. Hanks, Inc., San Francisco) contained 2.97 percent copper and 0.14 percent cobalt, which possibly represents an average mining grade for the deposit. An 18-inch channel sample on the 100 level, indicated on plate 60, contained 0.44 percent cobalt and 4.99 percent copper (U. S. Geological Survey assay). Other valuable metals in the ore are gold and silver. The weighted average of available assays indicates 0.14 ounce of gold and 0.59 ounce of silver per ton.

*Table 1. Production figures of the Jesse Belle mine.**

Period	Gold (ounces)	Silver (ounces)	Copper (pounds)[1]
1919	----------	71	12,268
1922	----------	**3,451	----------
1928	38.92	139	9,737
1929	14.00	77	5,686
1937	7.00	22	2,069
1942	19.00	49	6,182
1944	11.00	30	2,794
Totals	89.92	3,839	38,736

* From U. S. Bureau of Mines, Metal Economics Branch, San Francisco office.
** Source uncertain. Possibly from Daulton mine.
[1] Pounds of metal contained in concentrates.

Rosati Vein Zones

On the northern part of the Jesse Belle property are two parallel vein zones 200 feet part. These zones are explored by trenches and three shafts, each at least 40 feet deep. The shafts are not caved but contained no ladders and were not examined. The surface workings expose 310 feet of the vein zones of which 125 feet contain more than 5 percent gossan.

West Vein Zones

Along the west edge of the area several shear zones containing sulphide-quartz pods are exposed by trenches and shafts. Sulphide and graphite occur together in these vein zones. In the two shafts that were examined to a depth of 40 feet, no sulphide masses longer than 4 inches were seen. A total of 170 feet along the strike of the vein zones is explored by these workings.

Other Vein Zones

Both north and south of the Jesse Belle shaft are several quartz-sulphide pods explored by shallow pits. Although gossan stringers up to 18 inches in width are exposed in the pits, no veins longer than 8 feet along the strike were observed. A total of 240 feet of vein zones is exposed.

Vein zones similar to those studied in detail in the Jesse Belle area occur for at least a mile to the north and east of the property. Mineralogically and structurally the deposits are similar to the vein zones in the area mapped.

CONCLUSIONS

The small size of the Jesse Belle ore shoots and their moderate copper and cobalt content do not encourage the belief that considerable reserves of copper-cobalt ore are present. However, moderate tonnage of ore containing several percent copper and a few tenths percent cobalt may exist in the Jesse Belle and other vein zones in the area.

PART TWO

ECONOMICS AND TREATMENT OF ORES

THE MARKETING AND METALLURGY OF COMPLEX ORES IN CALIFORNIA

By Hadley R. Bramel *

OUTLINE OF REPORT

ILLUSTRATIONS

ABSTRACT

Mainly because of California's adverse geographical position with respect to markets for ores and concentrates of copper and zinc, complex sulphide ores bearing these metals, except during times of abnormally high metal prices, have attracted little attention. Following improvements in the differential flotation process during the twenties, production involving separation of such ores began in a small way in 1931 and reached a peak during the recent war. In 1945 zinc, largely from mining-milling operations in the Shasta and Foothill belts was the most important base metal. The 1945 production of 9,000 tons was about one-third of California's (imported) zinc consumption.

Accelerated industrial development of California and adjacent regions promises an ample metal market for a local zinc smelter. Meanwhile the development of sufficient ore to justify such an enterprise is hindered by high freight tariffs and the comparative smallness and wide distribution of known ore deposits. Local economic factors such as climate and accessibility to all types of transportation are generally favorable.

Some of the major economic factors affecting the production under competitive conditions of base metals in California are markets for metals, smelter schedules, and transportation by rail, water and highway. A study of rate-making principles leads to the conclusion that the bargaining power of the mining industry depends on understanding of motives and policy, steadiness of production, and the increase of volume which might result from decreased tariffs.

The metallurgy of complex ores, particularly pyritic ores of copper, zinc and lead, is reviewed in such detail as to acquaint a non-technical reader with the succession of steps resulting finally in the isolation of commercial metals. The milling of complex ores by differential flotation is described in greater detail partly because available accounts are usually too elementary or too technical to satisfy the needs of many of those in the mining industry who are interested in this subject.

The extraction of zinc from ores and concentrates by several alternative methods is given in some detail because zinc is the most abundant metal in the ores under consideration, and also because the need for a zinc smelter on the Pacific Coast, and possibly in California, has recently become apparent.

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HISTORY OF PRODUCTION FROM COMPLEX SULFIDE ORES IN CALIFORNIA

The term complex ore may be used to describe any ore from which two or more metals are eventually extracted and isolated. The term is more commonly used, however, in connection with ores from which two or more minerals are separated and isolated by mechanical or ore dressing methods. The complex sulfide ores referred to herein contain sulfides of zinc, copper and sometimes lead in a gangue consisting largely of iron sulfide and non-metallic minerals. Minor quantities of gold and silver are usually present. Deleterious elements such as arsenic and antimony have been reported and are to be suspected.

During the early days when most of the mineral deposits of the state were being prospected zinc ore had little value and was noted mainly as a penalty-bringing nuisance when found in association with other ores. Zinc minerals, furthermore, are not as a rule so easily or universally recognized as those of copper or lead. As a result of lack of value, desire to conceal, or simply from non-recognition of zinc minerals the zinc resources of the state have until recently been comparatively neglected.

Commercial success in the separation of zinc from copper in complex ores by differential flotation came as a result of world-wide research during the twenties. Previous to 1931 the zinc production of the state was from bulk flotation concentrates, from raw ore of shipping grade, and from generally unsuccessful pyrometallurgical operations.

In 1915 the General Electric Company experimented with ores from Shasta County with a sub-commercial electrolytic zinc plant. In 1922 the Shasta Zinc and Copper Company operated a commercial-sized plant for producing copper matte and zinc oxide fume in a reverberatory furnace. The plant was operated for only a few months and was evidently unsuccessful.

In 1925 the California Zinc Company built a 300-ton flotation plant to treat ores from the Rising Star and Afterthought mines of Shasta County. Unsuccessful experiments were made in an attempt to float copper and zinc minerals selectively. The plant was rearranged to make a bulk zinc-copper concentrate rejecting pyrite, the predominant gangue mineral. Recoveries of 90 to 96 percent of the zinc and 85 to 86 percent of the copper in a concentrate 43 to 49 percent zinc and 3.7 to 4.1 percent copper were reported. Production of zinc reached 17 million pounds in 1926. Concentrates were shipped to Belgium.[1]

According to available records the first successful attempt in California to apply differential flotation to complex sulfide ore on a commercial scale was at the Spanish mine in Nevada County, 1931-40.[2] Four separate concentrates were made with fair recovery—copper, lead, zinc and iron (pyrite with gold). A barite concentrate comprised the final tailing.

Attractive price incentives deriving from federal legislation of 1942 caused a general revival and expansion of base metal mining in California as well as elsewhere. Although locally copper from various sources was the leading metal through 1944, copper has since been surpassed by zinc derived largely from complex sulfide ores. The bulk of this production

[1] Tucker, W. Burling, Copper [Shasta County]: California Min. Bur. Rept. 22, pp. 138-162, 1926.

[2] Bradley, James, Mining and milling at the Spanish mine: Mining and Metallurgy, vol. 12, pp. 435-439, 1931.

has depended on differential flotation and has come from four widely separated mining-milling operations which reached in 1945 a combined milling capacity of 800 tons per day (table 1).

Each of the four operations was established on a semi-transitory war-plant basis. Under great stress to get into early production many compromises with sound engineering principles were necessarily made. Particularly was this true with respect to mine plant and mill installation and with respect to the development of ore for future operation. These conditions were undoubtedly responsible in part for the closing in 1945 of the Big Bend mine in Butte County and the Blue Moon mine in Mariposa County. In each case the immediate cause was reported to be loss of the shaft by caving.

Two operations, having combined mill capacities of some 500 tons per day are currently in production and although ore reserves are undisclosed it is understood that planning will be determined by economic trends.

Investigation and exploration of California mineral resources including the base metals is at the present time being continued with greater activity, perhaps, than at any time during the war. The work of which this bulletin is part is representative. The present exploration by a private company of the Afterthought mine in Shasta County may result in the founding of an important new zinc mining enterprise.

Table 1

Mine and mill	Product	Weight percent	Analysis percent		Recovery percent	
			Cu	Zn	Cu	Zn
Big Bend	Feed	100	2.01	12.55	100	100
Surcease	copper conc.	5.26	25.2	10.9	66.0	4.6
	zinc conc.	21.81	2.58	52.6	28.1	91.4
	tailing	72.93	.162	.68	5.9	4.0
Penn Eagle	Feed	100	2.43	12.0	100	100
Shawmut	copper conc.	8.53	22.58	13.23	79.10	9.41
	zinc conc.	19.70	1.16	52.43	9.38	85.98
	tailing	71.77	0.39	0.77	11.52	4.61
Mountain	Feed	100	2.28	4.54	100	100
Copper	copper conc.	14.50	11.98	4.26	76.20	13.61
	zinc conc.	5.08	1.46	49.10	3.26	54.99
	tailing	80.42	0.58	1.77	20.54	31.40
Blue Moon	Feed	---	---	---	---	---
Jenny Lind	copper conc.	---	---	---	---	---
	zinc conc.	---	---	---	---	---
	tailing	---	---	---	---	---

MARKETS FOR ORES AND METALS

The principal market center for refined metals in the United States is the vicinity of New York City. When not otherwise specified quotations generally refer to the price the industrial buyer is willing to pay for the metal in desirable shapes at the refineries near New York. Quotations at other centers such as the lead-zinc market at East St. Louis are lower approximately by the freight differential between there and New York.

Although the base metal production of the western states is far in excess of their consumption of finished metals this condition does not hold for California.

Refined lead and copper, however, are available on the West Coast in quantity, being derived largely from coast smelting of imported ores.

Refined zinc and zinc products used in California must come largely from more distant inland and eastern plants.

During the period 1940-44 the average annual consumption of zinc in California was between 20,000 and 35,000 short tons. The principal use was for galvanizing although 2500-5000 tons annually were used in brass-making by three plants.[3] In 1945 production of zinc from ore and concentrates, shipped by rail to distant smelters, was slightly under 9,000 tons.

Although the consumption figure cited represents abnormal wartime conditions, the state probably will continue to consume more zinc than it now produces. The rapid growth of industry, particularly the steel manufacturing and fabricating industries, will parallel increasing needs for zinc and other metals.

Zinc plants of a scale capable of supplying California's recent annual requirements, say 70 tons per day, have been built and have been proved to operate economically.

Smelting companies with plants widely distributed in the western states have been the principal buyers of California ores and concentrates. Zinc-copper concentrates produced in Shasta County in 1925-26, however, were shipped to Belgian smelters. During the war all local base metal ores and concentrates were shipped by rail, mainly by choice but partly perhaps because the high rates, crowded ships and terminals excluded from consideration ocean transportation of non-military cargo.

Because distinctive techniques and equipment are required for the efficient smelting of copper, lead, and zinc ores, reduction plants for each ore exist as separate units and although a few smelting works have facilities for smelting more than one type of ore, more commonly units are separated geographically. Because ores or concentrates of a given metal frequently contain important quantities of other valuable metals, smelters are variously equipped for extracting them and also have differing policies toward paying for them. The less valuable constituents of an ore—silica, iron, lime, sulfur, etc.—generally have a direct bearing on the desirability of the ore at a given smelter and therefore either a payment- or penalty-rating. Certain elements such as arsenic and antimony and in some cases zinc, may have deleterious effects in the smelting process and accordingly in quantities above certain tolerances bring penalties.

The majority of smelters in the western United States which treat important quantities of custom ore from numerous sources offer printed schedules or open schedules listing payments, deductions, charges and penalties based on the above considerations and on the numerous items of operating cost including cost of transportation, of refined or semi-refined metal, refining and sales, usually at eastern centers. When open schedules are not available, all negotiations between mine and smelter are perforce carried on confidentially.

Since smelting is a competitive industry, the calculation of the value of a given ore according to the terms of smelter schedules in some cases may not yield figures representing the maximum possible return to the miner. Bargaining power depends partly on the size and regularity of shipments and the ultimate tonnage at the miner's command; the extent to which he will allow himself to be bound by contract; and on the situation at the smelter with respect to abundance of supply.

[3] Ransome, A. L., personal communication.

Table 2. Typical open schedules for western and southwestern smelters.

Notes and definitions

E & M. J.: E & M. J. Metal and Mineral Markets, published weekly by the publishers of Engineering and Mining Journal (McGraw-Hill)

Unit: One percent of a ton of 20 pounds

Dry assay: A fire assay which gives lower results than the more accurate wet assay but which is commonly used as a basis for settlement.

Copper ore and concentrates

Payment for metals

Copper: 100% less 15 pounds per ton, less 2.5 cents per pound. Paid at E & M. J. quotation as of date of arrival.

Lead: 50% less 3.5 cents per pound at current quotation. (Only a few copper smelters pay for lead.)

Gold: 100% at $32.20 per ounce if gold is in excess of 0.03 ounces per ton.

Silver: 95% at U. S. Mint or Handy and Harman price (option of seller) if silver is in excess of 1 ounce per ton.

Treatment charges

Base charge: $3.50 per ton on ore having paid metal values up to $15.00 per ton. The charge will be increased 10% for the first $25.00 in excess of $15.00. Maximum charge $6.00 per ton for ores whose paid metal value exceeds $40.00 per ton.

Lead ore and concentrates

Payment for metals

Lead: 90% less 30 lbs., less 1.6 cents per pound. Paid at E & M J. quotation week preceding date of arrival.

Gold: $31.82 per ounce if 0.02 to 5 ounces per ton.

Silver: 95% if over ½ ounce per ton at N. Y. price on date of assay.

Copper: 90% (minimum deduction 15 pounds), less 6 cents per pound at E & M. J. quotation week preceding date of arrival. (Some lead smelters pay nothing for copper in lead concentrates.)

Iron: 6 cents per unit. (Some lead smelters pay a similar price for lime.)

Charges

Insoluble: 10 cents per unit. (Some smelters make no charge.)

Zinc: 6% free; excess charged for at 30 cents per unit. (Units free and charges vary.)

Arsenic: 2% free; excess charged for at 35 cents per unit. (Antimony and tin bring penalties at some smelters. Free units vary from 0 to 3. Bismuth is often heavily penalized.)

Sulfur: 2% free; excess charged for at 25 cents per unit. Maximum charge $2.50 per ton.

Treatment charges

$2.50 per ton on the basis of 30% dry lead assay. Debit 10 cents for each unit of lead under and credit 10 cents for each unit of lead over 30%. (Treatment charges are often based on the dollar value of the ore and are sometimes subject to variations determined by the current wage scales.)

Zinc concentrates

Terms for purchase of each concentrate are based on the analysis of a representative sample. The content of impurities is a determining factor, and relatively minute quantities of elements such as germanium, antimony, and cobalt, may render the concentrate unacceptable. The following schedule is sometimes used in the purchase of small lots, particularly during the development stage of the property:

Payment for metals (E. & M. J. quotation for week of arrival)

Zinc — 80% at St. Louis price for Prime Western zinc.
Lead — 80% of excess over 3% at New York price less 2.0 cents per pound.
Silver— 80% if 1.0 ounce or over as per schedule.
Gold —100% if 0.010 ounce or over at $27.024 per ounce.

Treatment charge

Base charge —$32.00 per dry ton, f.o.b. treatment-plant, based on 10½-cent zinc, labor $11.40 per eight-hour day, and a lead content of 3.0%.

Zinc price —Add or deduct $1.00 per dry ton of concentrate for each 1.0 cent increase or decrease above or below 10½ cents per lb.

Lead deficiency —Add 50 cents per dry ton for each 1.0% lead under 3.0% lead.

Insoluble and iron—Add 25 cents per dry ton for each 1.0% insoluble plus iron.

Labor —Add or deduct 1.0 cent per dry ton for each 1.0 cent change above or below $11.40 total labor cost. In applying this adjustment, use labor cost for second month preceding date of receipt of this concentrate.

Zinc concentrate schedule for electrolytic plant effective August 1, 1946

Delivery: f.o.b. cars, at treatment plant. A switching charge as assessed by the railroad is made on lots delivered by truck.

Settlement: Based upon a split of assays, if within the following limits:

Gold	.01 oz.	Zinc	0.5%
Silver	0.5 oz.	Lead	0.5%
		Iron	1.0%

Umpire: See below.

Payment for metals: Zinc: For 80%—at the East St. Louis Prime Western quotation.

Lead: For 80%—in excess of 3 units—at the New York quotation less 2 cents per pound.

NOTE: AS LONG AS THE GOVERNMENT PRICE REMAINS FIXED AT THE PRESENT LEVELS, PAYMENT FOR GOLD AND SILVER WILL BE AS FOLLOWS:

Gold: For 80%—if 0.02 oz. per ton or over—at $34.2425 per ounce.

Silver: For 80%—if 1 oz. per ton or over—at the prevailing price published by Handy & Harman based on either the Treasury's purchase price of newly mined domestic silver or the official price paid for bar silver in New York, whichever is higher. If the Treasury should discontinue the purchase of silver at a fixed price, the price paid shall be the official New York price for silver quoted by Handy & Harman.

Quotations: Metal prices as of date of sampling as published in the weekly market-news service (E&MJ Metal and Mineral Markets) of the Engineering and Mining Journal. Should settlement date fall upon a legal holiday or date upon which no quotation for a metal is issued, the next preceding quotation for that metal shall be used.

Treatment charge: $16.00 per dry ton of concentrate when the price of Prime Western zinc in East St. Louis is 4.0 cents per pound or less, which is the base charge.

Add $2.50 per ton for each 1 cent per pound rise in the price of zinc above 4.0 cents, fractions in proportion.

If zinc is under 45%, an additional charge of 50 cents per unit of deficiency under 45% will be made, fractions in proportion.

Penalties: Iron: 30 cents per dry ton for each unit of iron, fractions in proportion.

Insoluble: No penalty for insoluble.

Lead: Should lead content of concentrate fall below 3 percent, deduct from the amount payable for the metals in such concentrate, the sum of $1.00 per dry ton of concentrate for each unit of lead under 3 percent, fractions in proportion.

Sampling: Buyer has option of sampling and settling for each car separately or in any group up to four cars in a lot.

General conditions covering above schedule

1. The rates herewith apply on any size lot down to 5 tons. On anything under 5 tons, add to these rates a flat sampling charge on each lot of $10.00.
2. All federal or state taxes now or hereafter imposed and all duties and excise or other taxes levied by the United States or any foreign government shall be for shipper's account.
3. Base charges apply on the concentrates delivered at plant.
4. On the above schedule where the word "ton" is used, it is understood to be a ton of two thousand pounds avoirdupois; where the word "ounce" is used, as referring to gold and silver, it is understood to mean the troy ounce; and where the word "unit" is used, it is understood to mean a unit of one percent, or 20 pounds avoirdupois.
5. Weighing and sampling (at which seller or a representative may be present) as done by buyer according to standard practice, promptly after receipt of product, will be accepted as final. The absence of seller or a representative shall be deemed a waiver of the right in each instance. After sampling the product may be placed in process, commingled, or otherwise disposed of by buyer. In case of disagreement on assays, an umpire shall be selected in rotation from a list mutually agreed upon, whose assays shall be final if within the limits of the assays of the two parties, and if not, the assay of the party nearer to the umpire shall prevail. Losing party shall pay cost of umpire. In case of seller's failure to make or submit assays, buyer's assays shall govern.

In making preliminary surveys, however, a careful comparison of open schedules is sound procedure and, in conjunction with a study of freight schedules, should serve to narrow the search for a market to a few smelters with which direct negotiation is indicated.

Table 2 is a digest of typical western and southwestern open schedules showing representative terms of settlement at zinc, copper and lead smelters. Table 3 is a list of smelters within comparable economic transportation range of California. Comprehensive up-to-date writings on the subject of marketing ore are scarce.[4]

COMPETITIVE POSITION OF CALIFORNIA BASE-METAL MINES

An analysis of available local production costs shows one of the largest single items of expense to have been transportation of the products to market. To the few cases where ore has been smelted locally—the Shasta district in its heydey, Campo Seco 1910-18, and a few others—this does not apply. Transportation to market includes transportation from mill to railhead, railroad haul to smelter and freight of metal from smelter to refinery or to eastern markets. This cost has ranged from about 10 percent of the total value of the contained metals during periods of high metal prices to more than 30 percent in the case of certain zinc concentrates shipped recently. The present general range of value of mine-run copper-zinc ore in California is shown graphically in figure 1.

The geographical cost-handicap of base metal mining in California has been of the approximate magnitude to cancel the profit margin which might make a similar mine more favorably situated an attractive speculation. The absence of local markets, particularly a market for zinc concentrates, on the one hand, and high freight tariffs on the other, has resulted not only in inhibiting new ventures but also in curtailing or closing the zinc-copper operations of going concerns, and the

[4] Gardner, E. D., and Allsman, P. T., Open schedules for gold and silver ores and concentrates at western custom smelters: U. S. Bur. Mines Inf. Circ. 6926, 25 pp., 1936.
Fulton, Charles H., Buying and selling of ores and metallurgical products: U. S. Bur. Mines Tech. Paper 83, 43 pp., 1915.

Table 3. U. S. smelters and refineries within comparable transportation range of California.

Plant	Location	Operating company	Equipment	Capacity	Major source of raw material	Remarks
Anaconda	Anaconda, Mont.	Anaconda Copper Mining Company (A. C. M.)	8 reverberatories 7 converters, (see under "Remarks")	600 tons charge per furnace day (copper)	Butte ores and concentrates	Plant includes copper and zinc concentrates, electrolytic zinc plant, acid plant and phosphate plant
Miami	Miami, Ariz.	International Smelting Company (A. C. M. subsidiary)	4 reverberatories 5 converters	875,000 tons of charge per year	Output of Globe-Miami district. Concentrates and cement copper	A copper smelter
Tooele	Tooele, Utah	International Smelting Company (A. C. M. subsidiary)	2 reverberatories, 5 converters (see also under "Remarks")	400,000 tons of charge per year	Custom ores and concentrates	Includes a lead smelting department and a slag fuming plant for oxidized lead-zinc ores
Garfield	Garfield, Utah	American Smelting and Refining Company (A.S. and R.)	5 reverberatories, 8 converters	1,500,000 tons of charge per year	Concentrates from Magma and Arthur mills which treat Utah copper ore	Payment is made for lead in custom copper ores and concentrates
Hayden	Hayden, Ariz.	A. S. and R.	2 reverberatories, converters	360,000 tons of charge per year	Concentrates from Ray mine (Kennecott Copper Corporation).	A copper smelter
El Paso	El Paso, Tex.	A. S. and R.	2 reverberatories, converters (see also under "Remarks")	240,000 tons of charge per year	Custom ores and concentrates	Includes a lead smelting department, also zinc
Tacoma	Tacoma, Wash.	A. S. and R.	Reverberatory and converter plant	500,000 tons of charge per year	Custom ores and concentrates from Pacific Coast and interior	Includes an electrolytic copper refinery
Selby	Selby, Calif.	A. S. and R.	Lead blast furnace plant and refinery		Custom ores and concentrates from Pacific region	A lead smelter treating also ores of gold and silver
McGill	McGill, Nev.	Kennecott Copper Corporation	3 reverberatories, converters	1,200 tons of charge per day	Concentrates from ore from Ely mines	A copper smelter
Copper Queen	Douglas, Ariz.	Phelps Dodge	4 reverberatories, 4 converters	12,000 tons of copper per month	Concentrates of Ajo and Bisbee, Arizona—also from Mexico	A copper smelter

United Verde	Clarkdale, Ariz.	United Verde Copper Company (subsidiary of Phelps Dodge)	6 reverberatories, 4 blast furnaces, 8 converters	5,000 tons of charge per day	Concentrates and ores from Jerome	A copper smelter
Clifton	Clifton, Ariz.	Phelps Dodge	Reverberatories, 4 converters		Concentrates from mills at Clifton and Morenci	A copper smelter
Magma	Superior, Ariz.	Magma Copper Company	Reverberatory and converter plant	2,000 tons or more of copper monthly	Concentrates from mill at Superior	A copper smelter
Great Falls	Great Falls, Mont.	Anaconda Copper Mining Company (A. C. M.)	1,530 refining tanks—multiple system	162,000 tons of copper per year	Anodes from Anaconda smelter	Includes an electrolytic zinc plant and a copper wire mill
U.S. Metals Refining Company	Carteret, N. J.	U.S. Metals Refining Company	1,880 refining tanks, 4 anode furnaces, 3 cathode furnaces	240,000 tons of copper per year	Custom material, also blister from company smelters	Includes a copper smelter, lead smelter and lead refinery
Corpus Christi	Corpus Christi, Tex.	A. S. and R.	2 suspension roasting furnaces, leading and electrolytic equipment	About 200 tons of zinc concentrates per day. 25,000 tons per year	Concentrates—mainly from company mines in Mexico	Production started 1942. Includes acid plant. Residues containing copper, lead, and silver are sent to A. S. and R. smelter at El Paso
Bunker Hill Smelter	Kellogg, Idaho	Bunker Hill and Sullivan Mining and Concentrating Company			Concentrates from Bunker Hill and Sullivan, Hecla, Sunshine, Polaris, Star and Crescent mines	A lead smelter with 450 tons per day lead-zinc slag fuming plant, also facilities for treating custom zinc concentrates. Operated in conjunction with Sullivan Mining Co. electrolytic zinc plant
Amarillo	Amarillo, Tex.	A. S. and R.	Gas retort zinc smelting. Reflux refining equipment		Custom ores	
Josephtown	Josephtown, Pa.	St. Joseph Lead Company of Pennsylvania	Electrothermic zinc smelting equipment	Over 250 tons of zinc concentrates daily	Company mines in New York—also custom concentrates from Quebec and Argentina	Includes acid plant. Zinc metal and oxide are produced. Plant is on the Ohio River, navigable by by 800-ton barges
Palmerton	Palmerton, Pa.	New Jersey Zinc Company	Continuous vertical retorts. Reflux refining equipment			100 miles north of Philadelphia. 2 Waelz kilns, reflux distillation, retort distillation, residues and ores

term marginal has been popularly used as being generally descriptive of the local industry.

In view of the considerable production of these metals in California over a number of years it may seem odd that permanent centralized local smelters have not come into existence. Many contributory reasons can be given. The more important of these concern the individual magnitudes of the known California deposits.

With reference to geographical position it is generally true that successful smelting plants of the world have been located close to great mining districts or at tidewater within economic range of numerous mineral sources. The Selby lead smelter at Selby, California, although founded originally to treat California gold ores, evolved into a lead smelter and because of its tidewater location now receives lead ores from many parts of the world.

Excepting the Shasta district, which still holds relatively high rank in the history of copper mining and which was able to support several smelters during its more active years (1896-1918), the existence of base metal districts of similar rank in California is still to be demonstrated. The fact that the state has no district comparable to Butte, Coeur d'Alene, or Bingham, does not preclude the possibility that the recently initiated investigation of local zinc-bearing complex ores might reveal deposits having sufficient reserves to serve as a nucleus in assuring success of local reduction works.

Zinc production from 1942 to the end of the war was on a generally rising curve whose peak in 1945 represented an average of 25 tons of metal per day. Sustained production at such a figure approaches the scale necessary for the installation and economic operation of certain types of modern zinc plants.

A material fraction of the 1942-45 production, however, came from deposits whose individual output was small. Smallness is a factor which contributes materially to the direct expense of mining and also to the cost of discovering and developing new ore. The handicap is also generally reflected in inadequate financing, engineering, and management. A number of small isolated deposits, which under favorable circumstances might be productive, are far less valuable than a single deposit containing half their combined tonnage of ore. Practically the only means whereby a prospective builder of a local smelter could be convinced of a steady and sufficient supply of ore depending to any material extent on small mines would be by demonstrated, sustained production under price-cost conditions assuring ability to survive against out-of-state competition.

The financial, engineering, and management difficulties in operating small mines appear not only in getting ore out of the ground and into marketable form but also in marketing the product. Small and intermittent ore shipments allow little bargaining with transportation agencies and smelters. Time and information are sometimes not available for advantageous surveys of rates and schedules. The need for haste in receiving payment for ore shipments may preclude the most economical marketing procedures.

Metallurgical efficiency in separating local complex sulfide ores has depended more on the character of the ore than on size of plant, although unit costs are universally related to size of plant. Losses in milling have been on the average approximately the same as the cost of transportation of concentrates.

The ore deposits, large and small, in the Foothill belt and the Shasta district share the advantage of the mild winter climate—an advantage miners who have bucked snow in high altitudes and inaccessible regions should be particularly qualified to judge. The mines are in general favorably located with respect to hard-surface roads, rail terminals, and tidewater. The locations of the Foothill mines in relation to the Port of Stockton should be given particular note.

It is apparent that considered as a group, under a severe marketing handicap with no immediate relief in sight in the form of a local market, the California producers of base metal products from complex zinc-copper ores are in relatively weak competitive position. Grade of ore, metallurgical recovery, and local operating cost will determine this position for the individual case. The possibilities of improving the general outlook by way of improving transportation conditions will be considered.

TRANSPORTATION

Concentrates from complex sulfide ores may amount in weight from 20 to 28 percent of mill heads (table 1). In marketing these products both truck and rail transportation have figured and both have represented considerable and sometimes distressing items in operating cost. Since the ending of the war, ocean carriers have become available for non-military cargo and are worthy of consideration as supplementary means of transporting bulk commodities.

Although it is felt that nothing short of a drastic revision of marketing procedure would serve to raise the California industry to competitive parity with low cost producers elsewhere, even small improvements in transportation rates would be beneficial. A thorough survey of the field of transportation of mineral products would be timely. The following is offered without pretense of covering the subject in the manner suggested.

The producer of raw or semi-processed mineral products is entitled to inquire closely into the subject of freight tariffs particularly where they are distressing to the point of ruin to his enterprise. The miners' only alternative to the use of the common carriers—motor transport companies, shipping line services, and the railroads—is self-owned and operated transportation equipment or some form of charter service.

Federal regulation of rates and services offered by common carriers between states in the United States, although still in rapid flux, has only recently been unified under the single authority of the Interstate Commerce Commission. Its legal reason for existence is based on recognition of the fact that transportation systems have become vital to public and national welfare and its major functions involve the upholding of a just balance between the principles of equal facilities for all and of preservation of such facilities for national welfare.

The Commission has full control of rates and charges but generally exercises its authority passively other than to correct abuse or discrimination as between carriers and public or between carrier and carrier. The carriers work out their own rates and schedules alone and in conference organizations and must file them with the I. C. C. 30 days before they go into effect. Changes in rates may be brought about by the carriers themselves, within I. C. C. rules for such procedure; by the direct action of the I. C. C. with its powers of investigation and decision; by action of an individual or non-carrier who by demonstration before the board can show certain rates to result in discrimination or in some cases in insufferable distress. Particularly difficult cases may be carried to the federal courts. Consideration of diplomacy would strongly suggest that any application for more favorable rates be made first directly to the traffic manager of the carrier involved.

Since traffic department representatives are both the contact men and specific rate makers of carrier organizations the factors which motivate their rate-setting negotiations with shippers should be of interest.

Healy,[5] speaking particularly of the railroads, infers that the following are principal considerations as listed in order of decreasing importance:

1. Size of shipper
2. Disturbance to other rates
3. Disturbance to other shippers
4. Gain or loss in revenue
5. Extent of competition

The large shipper, that is, one whose products require the movement of thousands of cars per year, not only has high bargaining power because of the importance of his own revenue but because the revenue from the plants handling his products may be threatened as well. Furthermore a large shipper can afford a traffic manager who knows all the "angles" in rate matters and who would accept only the most favorable rates the carrier is able to set.

Railroad companies are inclined to hold a somewhat reverent attitude toward the general rate structure which represents the present state of long and arduous evolution. The chance of upsetting this structure by granting the desires of a particular shipper is therefore to be carefully weighed.

On learning of a rate reduction to one shipper other shippers of similar products would demand similar concessions.

The fourth consideration, gain or loss of revenue, is of less importance principally because the lack of well-formulated cost data makes the net profit or loss from a competitive move hard to evaluate. Gross revenue is preferred as being more tangible criterion for rate making, and in many cases a rate concession might result in lower gross revenue. In the case of mining, where heavier shipments would often result from reduced rates this item might be given more weight.

Concessions offered by competition are likely to be exaggerated by the shipper, a condition which makes this type of persuasion distasteful to the traffic man, particularly where he is in a position to know the underlying facts.

Healy's comments on these items have been abbreviated and therefore somewhat modified. Their gist seems to indicate that, where size of operation and other physical conditions relating to the shipper's business are fixed by circumstances, his most effective approach to the problem of securing rate reductions lies in having competent knowledge of rate structures and of stating his case with strict honesty as regards

[5] Healy, K. T., Economics of transportation in America, pp. 260-263, New York, Ronald Press Co., 1940.

competitive plans or offers. Where some elasticity is possible in volume of output he should stress the increase of gross revenue to the carrier. Other elements in the bargaining power of mine products involve the ease with which they may be handled and transported, the steadiness of production and the peculiarities of the rate structures applicable to them.

The Cost vs. the Price of Transportation. From the foregoing it is evident that railroad freight rates are based on many factors besides cost, some of them seeming decidedly irrational. The general defense of this policy capitalizes on the magnitude of the fixed cost items of rail operation and on the difficulties of untangling the costs of joint operation. It is commonly stated that two thirds of all costs do not fluctuate with traffic.

Although cost of service is becoming of increasing importance as a theory of rate making, the theory of charging what the traffic will bear, which grew directly from the monopolistic powers of early railroading, still prevails. Particularly is this so where water or other competitive transportation has exerted no influence. This is shown graphically in figure 2, which represents freight rates on ore or concentrates as submitted on inquiry by two western railroads in 1944. One route was inland and one coastwise covering similar distances. Comparison should be qualified by the probability that operating costs on the inland route should be higher. The graph also illustrates the pronounced effect of car loading on rates, a condition which, although in this case it may seem to derive from purely ''cost of service'' considerations, may also be interpreted in other ways.

Truck transportation services, although their actual operating costs are much easier to compute, have in general followed railroad rate-making policies.

The rate-making policies of water transportation services are somewhat unique and, although the sliding scale by which rates increase with commodity value is apparent, it is not so pronounced as in railroad rates. The relative bulkiness of commodities and ease of lading and unloading are of marked importance.

Some operating cost figures for truck transportation are given under that heading. Although trucks have been able to compete with railroads up to 800 miles, the distance is usually shorter. Some comparisons between rates and costs of transporting such bulk commodities as mineral concentrates over long distances by boat and rail are as follows:

Example of cost of iron ore transportation by Great Lakes steamers, 1920.

(Analysis from Healy, op. cit., pp. 151, 152)

SPECIFICATIONS:

Length	600 feet	Cost (estimated)	$1,000,000
Beam	60 feet	Operating period	240 days per yr.
Draft	20	Speed	11-12 miles per hr.
Capacity	12,000 tons of ore	Speed	275 miles per day

Cost of operating, full laden and with no intermediate stops ---------- 0.04¢ per ton mile

Cost (at this rate) between California and New York including Panama Canal toll: about $3.00 per ton

These cost figures, when it is considered that 1920 was economically speaking a high-cost year, may be suggestive of costs attainable today where heavy bulk commodities easily loaded and unloaded are carried between distant ports by full-laden specialized vessels. Published freight tariffs on such commodities, however, apply to the general cargo line carriers, whose operating costs on bulk cargo are unavailable. The following published rates indicate the range in the pricing of water transportation of bulk commodities in times of depression and inflation. The intercoastal rates for zinc and copper concentrates are not specifically listed but might resemble the following. Intercoastal and Gulf intercoastal rates are about the same.

	Rate per short ton
West Coast to East Coast Ports, 1946[1]	
Barite in 500 ton lots (unloaded at cost of cargo)	$7.00
Magnesite in 250 ton lots (wharfage not included)	8.00
West Coast to East Coast Ports, 1934[2]	
Copper pigs (difference in rates depending on port of origin)	$2.68 / 3.91½
Wheat in 500 ton lots	5.15
West Coast to Gulf Ports, 1946[3]	
Wheat in 500 ton lots	$6.00

[1] United States Intercoastal Tariff, Eastbound tariff no. 2-c, effective July 22, 1946
[2] United States Intercoastal Conference, Eastbound Tariff No. 2-B, effective May 23, 1934.
[3] Gulf Intercoastal Conference, Supplement No. 10, Eastbound Freight Tariff No. 1-B, effective June 24, 1946

Besides the shipping line services whose coastal and intercoastal rates on many commodities are available in published form the prospective shipper of mineral products has the alternatives of purchasing and operating vessels of his own, in which case he would be subjected to regulations governing industrial shipping, or, through the services of a ship broker, engaging or chartering a vessel of the tramp type. Assuming good management, suitable markets, and adequate tonnage to keep such facilities loaded on the outbound trip, a return cargo would be necessary to realize optimum economy. A shipping service of this type has been used to transport sulfur from Gulf Coast to California with a return cargo principally of lumber.

In connection with the cost of coastwise transportation it is noteworthy that pyrites with a value of less than $5.00 per ton at the mine has been shipped to the San Francisco Bay area from British Columbia in competition with pyrites from Shasta County.

A considerable body of general statistical data concerning the operating expenses of United States railroads is available in Interstate Commerce Commission and other reports. Analysis of such data[6] shows rather conclusively the importance of the nature of commodities and the extent of car loading on the actual costs of transportation. For the year 1932, the estimated average over-all costs of all freight service[7] was 0.83 cents per ton mile. For the same year the estimated average cost of less-than-carload-lot service (average carload 36 tons) was 7.0 cents per ton mile.

[6] Healy, op. city., pp. 160-198.
[7] Healy, op. cit., pp. 184, 185.

The analysis also shows the remarkable ability of railroads to cut expenses during years of low traffic volume. During 1929 it cost all railroads an average of 71.9 cents to get one dollar of revenue, and in 1931 it cost 77.1 cents. The maximum variation in this figure from 1923-37 was only 6 cents.

Some interesting rate structures have been made by the railroads in order to provide markets for commodities produced in large tonnages. The most favorable rates have usually been set to meet competition from water transportation. In order to meet such competition, rates of $2.00 per ton were set on bulk salt shipments between New York State and Chicago, 560 miles; rates from Louisiana to Chicago, 1004 miles, also for salt were set at $3.00 per ton.

The lowest rail rates in the West at the present time are probably for such low-priced bulk commodities as salt and coal. Coal is being shipped from Carbon County, Utah, to Fontana, California, 810 miles, for $4.35 per ton.

Purely from the standpoint of transportation expense base metal ores in general, because of their high density and imperishability, should hold favorable rank. Lump ore, because it can be dumped into and from gondola type cars, has the advantage over concentrates, usually shipped in box cars, which can be loaded and unloaded only semi-automatically.

Confronting all practical arguments that could be offered in behalf of reduced rates for base metal ores is the stronger argument of long standing custom as embodied in the rate structure for ores. As this particular rate structure probably took shape concurrently with the development of mining in the West the following testimony explaining informally its underlying theory as conceived by a western railroad official in 1884 should be appropriate.[8]

> I explained that there were a great number of mines in the country over which this road of ours runs, and in fact the majority of the mines have low grade ore. The people who own those mines know that the price they can afford to pay is a price that we cannot afford to take, provided it was the only business we had. A man of that kind comes to us and says, "We will put this rate down low, at almost cost," and in some cases we do it at cost. If in the future he gets ore that is worth $500 a ton, we want an advanced freight. We want to get even, as near as we can, on the carrying of this low grade ore. The road is entitled to have that for carrying this freight, no matter what it is, and therefore the freight is higher. A man comes to us to carry low grade ore. He is able to get his supplies, to work his mine and keep his men at work and get grub for them, and the farmer sells him grain, and it makes a general business through the country. That is the reason why we want to grade these ores.

Truck Transportation. Excepting unusual cases the loading factor of trucks used in transporting concentrates between mill and railroad is limited to approximately 50 percent. This is so because the tonnage of mine and mill supplies carried on the return trip is insignificant and other local outlets for large carrier capacity are generally lacking. If such outlets were available the average mining company would probably shun the additional management problems and disturbances to truck schedules which might be involved.

In truck haulage as in other operations where large volumes of material are handled or processed, unit costs are a function of the capa-

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[8] Testimony of H. M. Yerington, official of the Carson and Colorado Railroad (Owens Valley and western Nevada), in answer to a question as to the reason for ore classification by Senator Sullivan; in Testimony taken before the Judiciary Committee of the Senate of California in considering Assembly Bill No. 10 (Barry Bill) concerning the regulation of railroads: California State Legislature, 25th sess., April 1884, p. 39, Sacramento, 1884.

cities of the machines employed. Where conditions warrant the large capital investment represented by machines capable of maximum operating efficiency, practical limitations as to size of unit become a matter for consideration. Economies resulting in recent years from the application of mammoth earth moving equipment are notable. It is of interest, therefore, to note some of the limiting factors in highway transportation.

Specifications as to weight, clearance, speed, axle spacing and loading of vehicles to be used on state highways are set forth in the State Vehicle Codes. At the present time (1946) the maximum weight permitted on the roadway of a truck-trailer unit is 76,800 pounds. Such a unit must be at least 56 feet and not over 60 feet in length and have a specified spacing of axles. The factory-recommended pay load of typical modern heavy duty trucks ranges between 1.3 and 2.0 times the weight of the empty truck, the higher figure being reached with truck-trailer combinations.

The following figures [9] probably representing the most economic heavy, over-the-road truck transportation so far achieved (taking account of the present purchasing power of the dollar) are from performance records of experimental magnesium alloy bulk cement trucks equipped with hopper-bottom discharge gates. Note that trucks return empty.

Specifications: Over-all length, 60 feet; Capacity 35 cubic yards

Tractor	14,020 lb.		
Semi-trailer	4,840	Tare	25,910 lb.
Trailer	7,050	Pay load	50,890
	25,910		76,800
Savings over lightest steel type			5,580

Performance: (1945, 1946)

Permanente Cement Plant to—	Miles	Ton rate $	Ton mile rate $
Bakersfield	287.5	5.40	0.0190
Sacramento	136.5	3.40	0.0250
Modesto	96.5	2.60	0.0270
San Francisco	47.0	1.70	0.0362
		Average Ton Mile Rate:	0.0268
Average total miles per month			8,000
Average total pay load miles per month			4,000
Average total pay load miles per year			48,000
Total average annual savings over steel unit weighing 3 tons more			$3,859.20

These figures should be compared with those given by Gardner [10] for average costs of trucking ores and concentrates in the West during the depression year 1935.

Distance (miles)	Average cost per ton mile	Distance (miles)	Average cost per ton mile
Up to 1	$0.35	5-10	$0.09
1-2	0.22	10-20	0.06
2-5	0.12	20-100	0.05

THE METALLURGY OF COMPLEX ORES

The term metallurgy covers both the technology relating to the physical properties of metals and alloys and that relating to processes for isolating the metals from their ores. The latter technology, qualified as

[9] Permanente Metals Corporation, personal communication.

[10] Gardner, E. D., Costs of trucking and packing ore in western gold-mining districts: U. S. Bur. Mines Inf. Circ. 6898, 17 pp., 4 figs., 1936.

process metallurgy may be subdivided into ore dressing, hydrometallurgy, electrometallurgy, and pyrometallurgy. Each of these distinctive techniques may be used in appropriate sequence in advancing the state of a given metal from association with its ores toward a more marketable form.

Ore dressing is a technique particularly devised as an initial step, and its purpose is to discard valueless minerals and where necessary to separate valuable minerals from one another. Its effectiveness is limited to the partial isolation of minerals bearing a particular metal. Advantage is taken of the physical properties of minerals and its processes are therefore regarded as mechanical in that the minerals treated retain their identities and undergo no appreciable chemical changes. The froth flotation process is an example of an ore dressing method especially well suited to the separation of complex ores and will be described. Time will not be taken for the numerous ore dressing methods which have other important applications.

Hydrometallurgy is the name applied to processes involving the taking of metals into aqueous solution (as by leaching ores with acid) and subsequently recovering them by precipitation.

Electrometallurgy includes the various processes which depend on the utilization of electric current. In connection with the metallurgy of complex sulphide ores, hydrometallurgical and electrometallurgical methods are used jointly in certain cases during the final refining process. A brief description will be given of the electrolytic process for zinc.

Pyrometallurgy is distinguished from other processes in its application of relatively intense heat, usually by the burning of fuel. In the typical sequence of processes pyrometallurgical treatment follows ore dressing and has the objectives of separating the metals from the remaining non-valuable constituents of their ores and to a greater or lesser extent from one another, thereby converting them to more marketable form. Smelting and distillation are the major divisions of extractive pyrometallurgy and will be described.

Differential flotation,[11] the separation by the froth flotation process of three or more constituents of an ore, is an outgrowth of the simpler bulk flotation process by which sulfide minerals as a class are separated from earthy minerals such as quartz and calcite. Differential flotation at the present time has no rival in the concentration of many complex ores, and its importance can be measured in this country in terms of tens of millions of tons of ore treated annually.

In the course of flotation minerals undergo practically insignificant chemical changes, although their chemical constitution is definitely involved, and the process is therefore classed as mechanical. It is well suited to large-scale and comparatively small-scale operations.

Flotation depends on the principle that a mineral surface can be so conditioned by minute quantities of certain organic reagents in water solution as to become resistant to wetting by water. As a consequence a mineral surface so conditioned, when submerged in water will adhere to an air bubble on contact. Where the mineral particle is smaller than a

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[11] Gaudin, A. M., Flotation, 552 pp., New York, McGraw-Hill Book Co., Inc., 1932. . . . Principles of mineral dressing, pp. 334-423, New York, McGraw-Hill Book Co., Inc., 1939.

Taggart, Arthur F., Handbook of mineral dressing, ores, and industrial minerals, sec. 12, New York, John Wiley & Sons, Inc., 1945.

certain critical size, say one millimeter, an attached bubble may be capable of levitating it to the surface.

Practical flotation is carried out in a water suspension of fine-sized particles. Such a suspension, called a pulp, may consist of one pound of solids to each three or four pounds of water. Levitation of conditioned particles is secured by providing a constant stream of rising air bubbles.

Ordinarily bubbles would burst on arriving at the water surface. To prevent this and the consequent resubmergence of entrained minerals organic frothing reagents are added in small quantity to the pulp. The resulting froth continuously forming at the water surface rises as a column and can be scraped from or allowed to overflow the flotation machine, thereby completing the separation cycle.

The mechanical reason why certain (floatable) surfaces will cling to bubbles of air in a surrounding of water, whereas other (nonfloatable) surfaces will not is explained by the forces of adhesion between water and the surface in question as compared with the forces of cohesion within the water. As an example, a drop of water will spread thinly on a clean quartz surface, whereas a similar drop on an oiled surface will contract into a sphere-like globule. The forces of adhesion between water and oil are evidently less than the forces of cohesion within the drop of water. The same reasoning explains the behavior of a bubble held in contact with a submerged surface. A bubble would not disrupt the strong bond between water and quartz but would provide the necessary "hole" to allow the water to pull itself partly away from the oiled surface.

Surfaces differ in magnitude of wettability, and a satisfactory measure of this quantity, which is also a measure of relative floatabilty, is the contact angle, the angle measured in the water between the solid surface and the air-water interface. The angle is characteristic for a uniform surface whether the measurement be made on a droplet of water surrounded by air or on a bubble of air surrounded by water. A contact angle of 90° does not signify twice the floatability of a 45° angle. A linear scale of floatability is the quantity $E\ (1\text{-}\cos\Theta)$ in which E is the surface tension of the solution and Θ is the contact angle.

It has been established that pure crystalline minerals are inherently unfloatable and that seeming exceptions are so because of natural or accidental surface contamination. Floatability, in fact, seems to be restricted to the hydrocarbon class of compounds, or substances containing hydrocarbon groups. Paraffin wax, for example, is one of the most readily floatable solid substances (contact angle 105°). Likewise many substances can be made floatable by smearing their dry surfaces with various oils or waxes. Such a method of imparting floatability has little resemblance to the modern process of selective froth flotation. Petroleum oils are sometimes used to increase the contact angle on minerals that have been treated previously by reagents discussed in the following paragraphs.

Investigation of the reagents capable of forming water-repellant coatings selectively on water-wet mineral surfaces has established them as comprising a special class of unsymmetrical organic molecules. These molecules may be visualized as elongated structures with one termination of hydrocarbon character and an opposite termination of chemically reactive nature.

As might be inferred, the physical and chemical behavior of such molecules is dependent on orientation. The hydrocarbon aspect is nonreactive, water-repellant and in general similar to, say, the petroleum oils. The opposite aspect is active, water-avid, capable of solution and ionic dissociation in water, and also of bonding with greater or lesser selectivity with the surface ions of minerals. The members of this large class of reagents are called collectors or promoters.

A further widely accepted conclusion from research is that collectors in concentration ordinarily used in flotation, form coatings (with hydrocarbon aspect toward water) approximately one molecule thick and approximately complete. A film of this relative thickness suffices for strong flotation and accounts for the small amount of reagent required. Typically one pound of collector will activate 10 to 50 tons of ore.

Understanding and control of the physical-chemical mechanism of the bonding between collectors and mineral surfaces is the basis of selective flotation. In some cases the mechanism is precisely understood and in others it remains obscure. The following are a few of the rules and general lines of investigation that may be followed in a given flotation problem.

From a practical standpoint collectors may be classified in two broad groups:

1. Those which have collecting power principally for sulfide surfaces. This group includes the popular xanthates, the thiophosphates (aerofloats) and the organic sulfides.

2. Those which are primarily used in the flotation of nonsulfide minerals but which have collecting power for sulfides as well. This group includes the soaps or soap-like acids, the wetting agent type of collectors and the new and interesting cationic collectors.

Appropriate choice of collector may improve selectivity. As an example ethyl xanthate might float a responsive sulfide in the presence of a sluggish one. To float both minerals together amyl xanthate might be more suitable.

In many cases the quantity of collector is critical to selectivity. A starvation amount of collector may successfully float a responsive mineral from a nonresponsive one. In certain cases one mineral may abstract most of the collector in solution, leaving little in excess.

Control of the chemical weather in flotation is one of the most important means of securing a desired result. The various reagents used for this purpose are called modifiers or controllers. These include common acids and bases for regulating the pH (relative alkalinity or acidity); numerous inorganic salt-type reagents such as copper sulfate and sodium cyanide; substances that exhibit colloidal properties such as starch and water glass; and complex organic salts exerting detergent or cleaning action against the deleterious coatings of minute solid particles. The regulation of temperatures, the sequence in which reagents are introduced and the time during which they may act are also factors subject to control.

The objects sought by certain maneuvers are well understood. The zinc sulfide, sphalerite, for example, is not activated by ordinary amounts of, say, xanthate. The surface of sphalerite, however, may be altered to one of copper sulfide by adding a copper salt to the pulp. The mechanism here is one of substitution in which copper is precipitated and zinc ion given up to the solution. Conversely it is possible (but usually impractical) to deactivate the sphalerite by dissolving such a copper sulfide film.

A more subtle principle underlying the action of flotation controllers is that of competition between ions in solution.

The class of reagents called "frothers" has already been mentioned. Molecularly they resemble collectors and although sometimes capable of exerting collecting action they are more often chosen purely for a role in the mechanics of flotation.

The column of froth in a flotation machine comprises a cellular structure of thin-walled films of water studded with mineral grains. Although the activated particles are more or less firmly held to the water-air interface, and are consequently unable to leave a closed cell, many water-wet unactivated grains find their way into the narrow walls. As the column rises bodily, bubbles coalesce, and excess water drains back into the pulp through the maze-like but continuous films. The function of this counter-current is to sweep back the accidental fraction of the mineral burden.

By appropriate choice and quantity of reagent it is possible to secure an optimum quality of froth. Froths are characterized as tough, dry, brittle, lacy, and watery. Popular reagents are pine oil and cresylic acid. As a rule these have little collecting action.

Flotation Machines and Technology. Flotation machines of commercial practice comprise groups of interconnected individual cells. Each cell is a compartment, usually rectangular in plan, having wood, metal, or concrete walls and is provided with inlet and outlet ports for the admission and ejection of pulp. Two opposite sides of each cell serve as weirs for the overflow of froth, and launders are provided for its collection and removal. Two methods are employed for the introduction of large volumes of finely divided bubbles of air and for the agitation of the pulp. In the pneumatic type of machine these results are secured by air under pressure introduced through jets situated near the bottom of the cell. In the mechanical type of machine intense agitation is provided by an impeller mounted on a vertical shaft. Air may either be drawn in through pipes by suction created by the impeller or forced in by external equipment. Means are usually provided for the adjustment of pulp circulation, froth overflow weirs, and air introduction.

The merits of the various types and makes of machine are much debated, and choice seems to be governed partly by personal preference. Capacity, cost of upkeep, ease of cleaning, dependability, and many other factors besides metallurgical performance may determine choice. In general pneumatic machines are recommended for sensitive operations such as cleaning, and agitation machines are preferred for roughing.

Since the flotation of each activated particle in the pulp depends on making physical contact with an air bubble, time is required to afford sufficient opportunity to each of the countless numbers of particles involved. To secure a necessary floating time ranging between 5 and 15 minutes cells are connected in series of 6 to 12. As a rule the most floatable minerals appear in the froth of the first cell in the series. Often this portion of froth is segregated as a finished concentrate. The froth from subsequent cells may comprise a middling concentrate containing a large fraction of undesirable minerals partly in the form of locked particles (particles composed of two or more minerals). The middling product is usually returned to a preceding point in the mill circuit for regrinding and reconditioning. The pulp flowing from the last cell is the flotation tailing. If it contains a valuable mineral which has been purposely depressed during the first flotation it may be sent to a conditioning tank and subsequently to a second flotation circuit.

In the differential flotation of complex sulfide ores it is generally difficult in a single flotation operation to achieve high extraction in the form of a concentrate of marketable grade. It is often expedient, therefore, to set the conditions of the first or rougher stage of flotation for a high extraction of the desired mineral in the form of a concentrate containing a large fraction of contaminating material. This concentrate, then, may be reconditioned for greater selectivity and subjected to one or more cleaner flotations. The tonnage of material sent to each successive cleaning stage becomes smaller, the time for flotation more subject to control and optimum selectivity can be achieved. The laws of chance also operate to preclude the repeated accidental flotation of unactivated particles. Disposal of the cleaner tailing depends on the value and nature of its mineral content. It may be sent backward or forward in the mill circuit for retreatment or rejection.

The Flotation of Complex Sulfide Ores in California.[12] Complex sulfide ores mined in California have ranged from disseminated to massive pyritic types. The ores of recent importance, derived largely from the Shasta and Foothill belts, have been mainly of massive type comprising intimate or banded mixtures of pyrite, sphalerite, chalcopyrite, galena, silver and gold. In relative abundance the minerals have occurred in approximately the order given. Galena has been of minor importance, non-metallic gangue minerals have been present in amounts approximating 10 percent, and the precious metals are of variable but, on the whole, of small importance. Typical base metal analyses are given in table 1.

Individual smelters generally specialize in one metal, and to realize maximum profit from complex ores under ordinary marketing conditions it is necessary to separate the metals by milling as completely as is economically feasible. Zinc particularly should be kept low in copper concentrates. Lead in copper concentrates is in cases paid for at low rates. Zinc concentrates below a certain grade are usually penalized.

Massive pyritic ores containing economic quantities of zinc and copper (and perhaps lead) are not uncommon throughout the world and the general scheme for treating them by flotation has become somewhat standardized [Rouyn, Quebec[13]; Flin Flon, Manitoba[14]; Superior, Arizona[15]; Balmat, New York[16]]. In outline the scheme involves: depression of pyrite and sphalerite with cyanide and other reagents such as zinc sulfate; flotation in a neutral circuit of the copper minerals with

[12] Bradley, James, Mining and milling at the Spanish mine: Mining and Metallurgy, vol. 12, pp. 435-439, 1931.
Messner, W. E., and Bein, H. H., California producer solves difficult flotation problem: Eng. and Min. Jour., vol. 145, no. 11, November 1944, pp. 68-71.
Hecla's California project, Red Cloud Mines, Inc.: Mining World, vol. 6, no. 4, April 1944, pp. 11-13.

[13] Parsons, A. B., Selective flotation of a copper-iron ore at the Eustis mine in Quebec: Eng. and Min. Jour., vol. 123, no. 3, January 14, 1927, p. 84.

[14] Oldright, G. L., Treating a complex ore: U. S. Bur. Mines Tech. Paper 499, 101 pp., 1 fig., 1931.
Lowe, S. P., The concentrator and cyanide plant of the Hudson Bay Mining and Smelting Company, Limited: Canadian Inst. Min. Metallurgy Trans. 1935, pp. 163-175, 1935.

[15] Caldwell, Edward J., Milling and smelting of the Magma Copper Co., Superior, Arizona: U. S. Bur. Mines Inf. Circ. 7300, 38 pp., 5 figs., 1944.

[16] Casale, J., St. Joe's Balmat mill-problem in four dimensions: Eng. and Min. Jour., vol. 147, no. 11, November 1946, pp. 56-62.

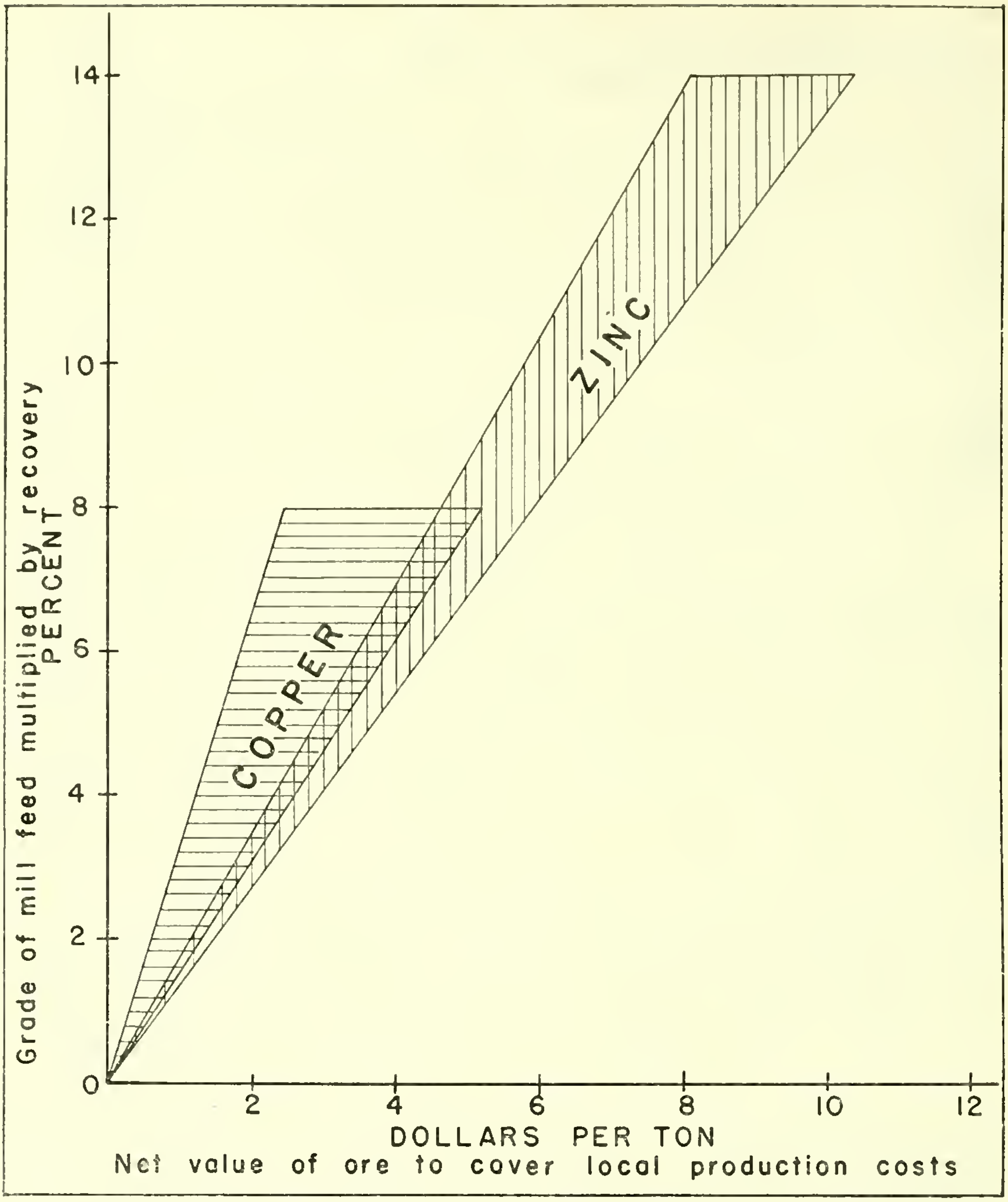

FIG. 1. Graph illustrating the approximate range of value of zinc-copper ores mined and concentrated in California in 1946. Values are based on net payments to the producer for concentrates of typical grade shipped by rail to various western smelters with electrolytic copper at 13.8¢ a pound FOB New York, prime western zinc at 8.7¢ per pound, East St. Louis. Payments for lead, gold, and silver are not included. *Example:* If 4 pounds of copper and 10 pounds of zinc were recovered from 1 ton of ore, the range of payments for the resulting concentrates would be

For copper concentrate	$1.20	to	$2.60
For zinc concentrate	5.80	to	7.40
Net value per ton of mine ore to cover all local production costs	$7.00	to	$10.00

one or more of several common collectors; activation of the sphalerite with copper sulfate in a high-lime circuit for the depression of pyrite; and flotation of the zinc with a selective collector (such as sodium aerofloat) and a selective frother (such as B-23 or one of the wetting reagents such as OT). One to three stages of cleaning are common. With particular reference to California experience, a few of the problems associated with this scheme of treatment will be discussed.

In the laboratory, the separation of an artificial mixture of copper (or lead), zinc and iron sulfides would present little difficulty. The separation of similar aggregates formed by nature, however, is regarded as one of the more difficult flotation problems.

Two of the uncontrollable characteristics of natural ores are the fineness of individual mineral grains and the manner in which they are bound together. These characteristics set the maximum size to which the ore must be ground in order that individual species shall be substantially free. Complex pyritic ores in California as well as elsewhere afford extreme examples of fineness of grain and concomitant features prejudicial to ease of separation.

Not only is there an economic grind-limit because of the costliness of grinding, but all ore dressing processes seem to function best on particles of a certain size-range and flotation is no exception. Flotation according to present experience works best on the range of particles passing a 65 mesh and retained on a (hypothetical) 600 mesh screen. Recovery and selectivity drop markedly on particle sizes below this range. Such slimes, regardless of mineral character tend to appear abundantly in flotation froth and because of their enormous surface areas abstract inordinate amounts of reagent. Further detrimental effects are caused by the tendency of slimed particles to alter the surface of coarser particles by the formation of coatings.

Grinding machines are notoriously unequal to the task of reducing solids to particles of equal size. In grinding to a given maximum size—the size required for liberation—the bulk of the ore is unavoidably reduced to undesirable fineness. The softer and usually the more important minerals suffer most.

Where economic considerations limit the mill flowsheet to one of comparative simplicity the problem of controlling unavoidable slime reoccurs in each flotation step, and although skill in the manipulation of reagents can minimize its effects, results are seldom wholly satisfactory.

Many millmen have doubtless pondered and experimented with schemes for splitting this troublesome fraction from the main flow of pulp and treating it as a separate product. Recent improvements in the design of centrifugal classifiers have made such a separation economically feasible but the problem remains of separating the minerals of the unwieldy slime fraction.

No proved theoretical reason exists why flotation cannot be adapted to the problem of separating extremely fine particles. Recent work on the flotation of cement copper precipitates shows promise in this respect. Many data indicating the limited range of flotation efficiency seem to have been derived from experiments in which adjustments favored the recovery of relatively coarse particles in the presence of an enormous range of sizes[17].

[17] Gaudin, A. M., op. cit. 1939, pp. 402, 403.
Taggart, A. F., op. cit., sec. 12, pp. 92-95.

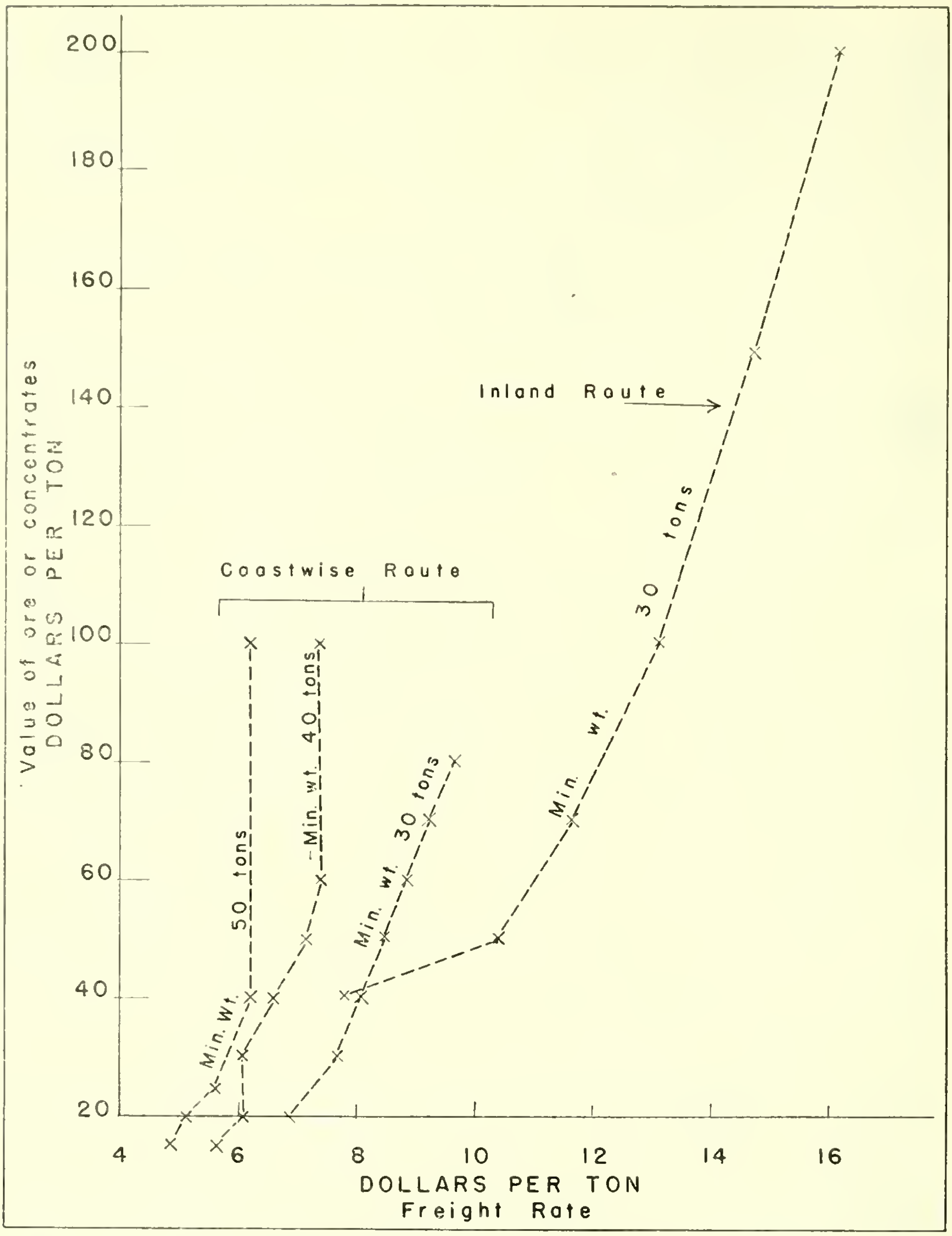

FIG. 2. Rates offered by two different railroads over similar distances in the west.

From the standpoint of flotation practice a detrimental characteristic of complex ores containing zinc involves the chemical history of the ore previous to the instant of flotation. The separation of copper (or lead) sulfide minerals from sphalerite is wholly dependent on the different make-up of the mineral surfaces.

A well-recognized general principle holds that mineral surfaces together in the same solution tend in time to become alike. The tendency of sphalerite to acquire a copper sulfide coating in the presence of copper minerals—especially with abundant pyrite—is particularly marked. The reaction begins with the breakdown of pyrite in the presence of oxygen and water resulting in the formation of sulfurous acid; the acid dissolves copper and deposits it on the sphalerite along the very surfaces or weakness that rupture easily in the subsequent crushing and grinding operations. The activation of sphalerite may be well advanced previous to mining and proceeds with acceleration after mining and during grinding.

California ores differ considerably in degree of inadvertent activation previous to flotation. Metallurgical difficulties from this as well as other causes are reflected in the results presented in table 1.

To minimize such preactivation it has been common practice in California to transfer mined ore to the mill as quickly as possible. This need for haste imposes limitations on mining methods and discourages the storage and blending of ore in order to provide more uniform mill feed. The consequent surges in grade of ore are generally considered by the mill operators as being more detrimental to metallurgical results than all other causes combined. The necessarily hasty changes in operating practice allow little opportunity for systematic experiment. At the Surcease mill improved recovery of zinc followed the installation of a scavenger flotation circuit.

As a further measure against preactivation it has been common practice to neutralize the acidity in the ore by adding basic reagents to the ball mill. The nature of the reagent appears in the case of certain ores to be critical and with others not. Lime and soda ash were equally suitable at the Surcease mill, whereas sodium bicarbonate was found best at the Eagle Shawmut mill. Agreement was general that the pH for optimum copper flotation was that of slight alkalinity, preferably about 7.3.

The general cause for each of the difficulties mentioned lies in the fact that the troublesome fraction of the particles subjected to flotation present surfaces not entirely characteristic of a distinct mineral species. When the specific cause is one of surface alteration, chemical or mechanical (slime coatings) it is usually at least theoretically possible to find a similarly straightforward remedy. The principles of cleaning mineral surfaces either chemically or mechanically are probably widely known. On a laboratory scale Norman and Ralston have demonstrated procedures which have "resulted in many new separations of minerals and an increase in the sharpness of selection in some otherwise imperfect separations."[18] Although the dispersal of slime coatings by the use of reagents is fairly common practice the use of inorganic cleaning reagents largely remains as a field for exploration.

It is known that cyanide in 1 percent concentration is capable of depressing and probably of cleaning the copper-altered surface of

[18] Norman, J. E., and Ralston, O. C., Conditioning surfaces for froth flotation: Am. Inst. Min. Met. Eng. Trans. 1939, vol. 134, p. 80, 1939.

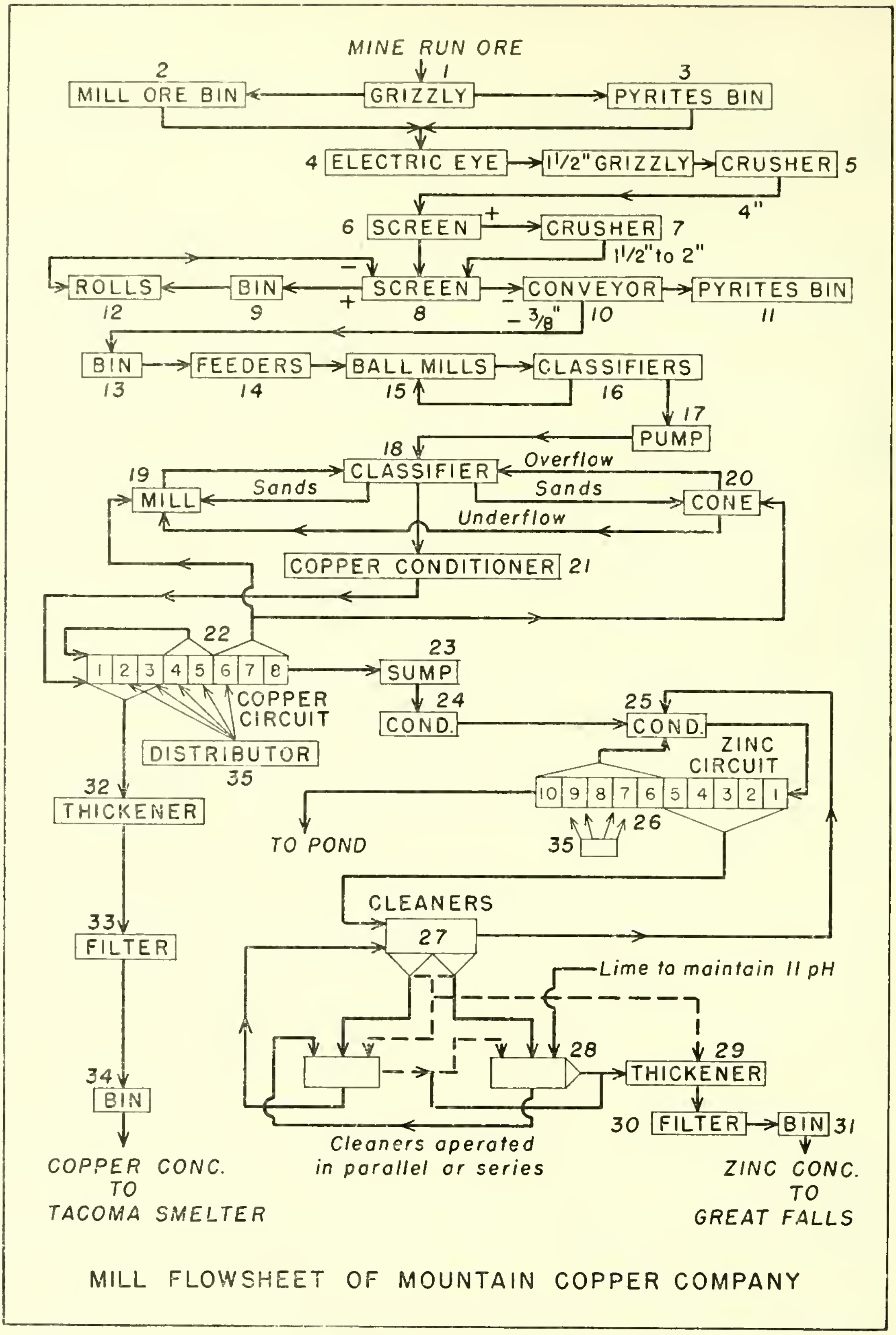

FIG. 3. Flow sheet for Mountain Copper Company's modern 350-ton flotation plant at Iron Mountain, Shasta County. *Reprinted from* Engineering and Mining Journal, vol. 147, no. 9. *Legend:* (1) Grizzly, 11-in.; (2) mill ore bins; (3) pyrites bins; (4) electric eye for tramp-iron detection; (5) Allis-Chalmers 6K gyratory crusher; (6) link-belt screen, 1¼-in.; (7) No. 4 McCully crusher; (8) Tyrock screen, minus ⅜-in. sizing; (9) surge bin; (10) shuttle conveyor to spread mill ore and carry pyrites to belt leading to bin; (11) pyrites storage and shipping bin; (12) Anaconda 48- by 16-in. rolls; (13) fine mill ore bin; (14) two Hardinge feeders; (15) two Allis-Chalmers 7- by 6-ft. ball mills; (16) two Dorr SB classifiers; (17) sump with 3-in. B-frame Hydroseal sand pump; (18) Dorr DSFB bowl classifier; (19) Allis-Chalmers 6- by 10-ft. regrind ball mill; (20) 5- by 6-ft. cone; (21) copper conditioner; (22) eight 56-in. Fagergren flotation cells; (23) sump; (24) No. 1 zinc conditioner; (25) No. 2 zinc conditioner; (26) ten 56-in. Fagergren level-type flotation cells; (27) two 56-in. Fagergren cleaner cells; (28) two single 56-in. Fagergren recleaner cells; (29) Dorr zinc thickener; (30) Eimco disc filter (zinc); (31) zinc concentrate storage bin; (32) Dorr copper thickener; (33) Eimco disc filter (copper); (34) copper concentrate storage bin; (35) xanthate distributor, or "spider."

sphalerite. To use this costly reagent in such high concentration would involve the installation of complex and expensive equipment for its regeneration. However, cyanide is commonly used in lower concentration (0.1 percent).

Ammonia might also be suggested as a solvent and complexer of copper coatings on sphalerite. Its economic success as a leaching agent on 0.9 percent carbonate copper ore [19] commends it as a subject for experiment.

It is worthy of note that a cheap method of cleaning activated sphalerite would make possible the storage and blending of complex ore.

The flowsheets of the four California mills listed in table 1 were alike in general scheme, differing mainly in such details as the number of stages of grinding and cleaning and as to disposition of middling products. The simple flowsheet of the Surcease mill (Big Bend mine) was approximately duplicated for ore from the Blue Moon mine (see fig. 4). This may be compared with the flowsheet at the Mountain Copper mill (fig. 3). The Shawmut mill (Penn mine) is of intermediate complexity. Reagent usage, for reasons already mentioned, has been subject to much experiment.

The Smelting of Copper, Lead and Zinc.[20] The pyrometallurgy of metallic ores includes smelting proper, distillation, and such preliminary treatments as roasting and sintering. The usual objects of these processes are to separate the metals from the non-valuable constituents of their ores and to a greater or lesser extent from one another. Although the metal in the metallic state is the most commonly sought end-product certain metallic compounds such as marketable oxides are in some cases intentionally produced. Another important application of pyrometallurgy is as an intermediate means of concentration, the products of which are to be refined by electrolytic or other methods.

In pyrometallurgy as in some other technological fields there are diverse possible methods for achieving almost identical results. Practically, however, choice is restricted by numerous economic considerations. The desired reactions must be brought about by cheap fuels and reagents such as coke, natural gas, air, limestone, and silica. These limitations in conjunction with the long accumulated fund of experience and the never-ending drive to replace men by machinery have resulted in a tendency toward standardization. On the other hand there is great variety in the make-up of ores, variety also in the local market for products and by-products, available fuels, reagents, man power, and power, and in fact in the local traditions of how things should be done. It is to be expected therefore that pyrometallurgical practices should embrace a broad intricate field of knowledge. An attempt can be made herein to mention only a few of the more standardized methods with emphasis on the subject most pertinent to regional needs, namely the extraction of zinc.

The term smelting is loosely used to include distillation. Properly, smelting implies fusion of the ore, a condition which may or may not exist during distillation.

Both smelting and distillation take advantage of interreactions between the constituents of ores and certain added materials at elevated

[19] Hofman, H. O., and Hayward, C. R., Metallurgy of copper, p. 303, New York, McGraw-Hill Book Co., Inc., 1924.

[20] Liddell, D. M., Handbook of nonferrous metallurgy, 2d ed., 2 vols., New York, McGraw-Hill Book Co., Inc., 1945.

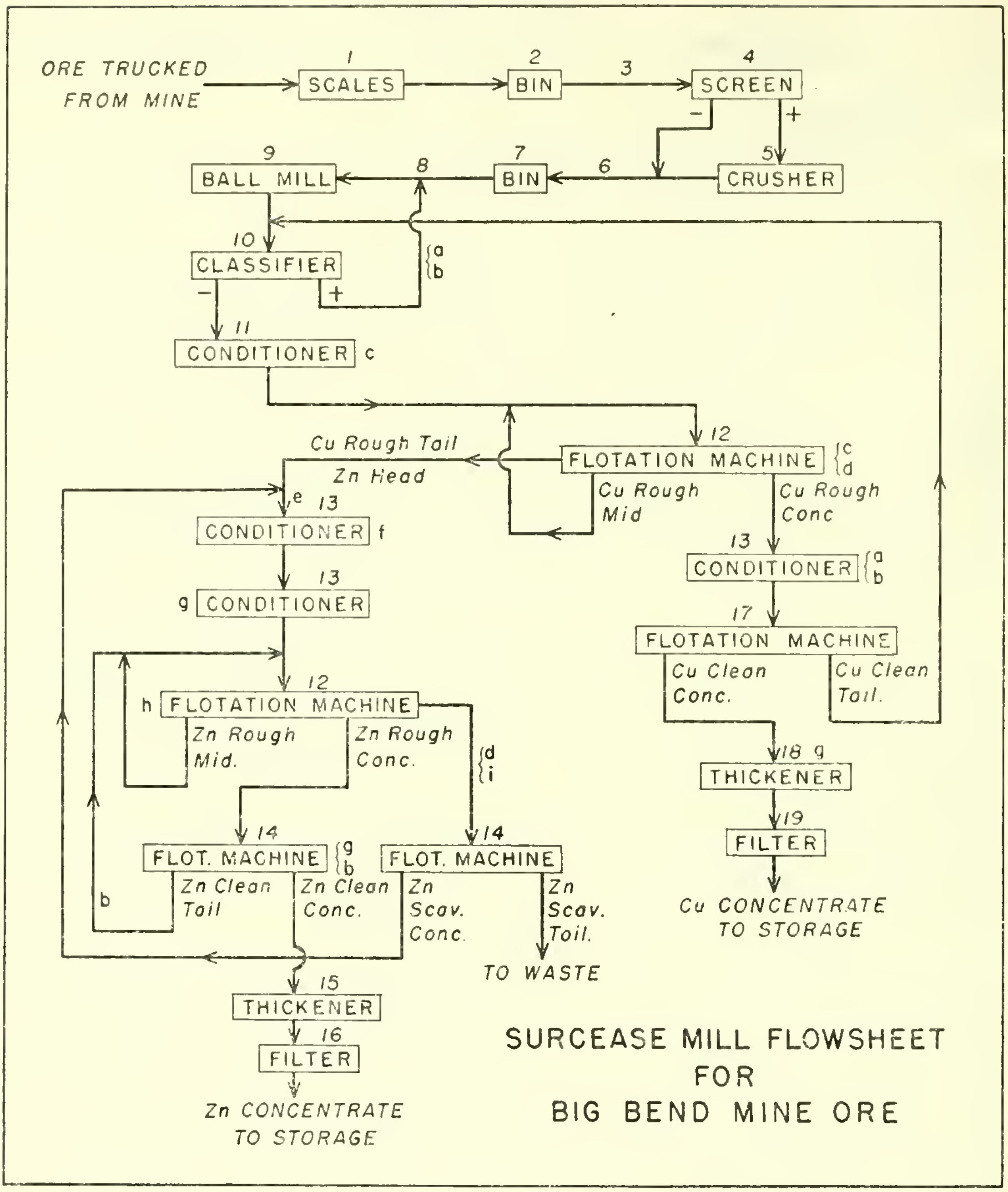

FIG. 4. Flowsheet of Surcease mill for Big Bend ore. *Reprinted from* Engineering and Mining Journal, vol. 145, no. 1. LEGEND: *Equipment*—(1) Platform scales, 10-ton; (2) coarse-ore bin, 100-ton; (3) pan conveyor; (4) vibrating screen; (5) jaw crusher, 10- by 24-inch; (6) belt conveyor; (7) fine-ore bin, 150-ton; (8) belt feeder, variable drive; (9) ball mill, 6- by 5-ft.; (10) classifier, 54-in. duplex; (11) conditioner, 5- by 4-ft.; (12) Fagergren flotation machine, four 44-in. cells; (13) conditioner, 5- by 5-ft.; (14) Fagergren flotation machine, two 44-in. cells; (15) thickener, 12-ft.; (16) filter, 6- by 8-ft.; (17) Fagergren flotation machine, one 44-in. cell; (18) thickener, 6-ft.; (19) American leaf filter, 4-ft. *Reagents*—(a) $ZnSO_4$; (b) NaCN; (c) 40_4; (d) B23; (e) 208; (f) $CuSO_4$; (g) CaO; (h) cresylic acid; (i) 301.

temperatures. The physical mechanism by which separations are accomplished differ in the two methods. In distillation separation depends on the vaporization of one or more constituents while the others remain in the solid or liquid state.

Separations effected in smelting depend on the formation of liquid compounds whose physical properties differ to such an extent that separation takes place by stratification automatically and in a reasonable time under the influence of gravity.

Smelting is as a rule conducted most efficiently and economically on ores of a single base metal, although claims to the contrary have been made for the Waelz process which involves distillation of volatile metals followed by smelting of those less volatile. In general the metals of mixed ores interfere in varying degree and this fact explains the existence of smelters devoted almost exclusively to the treatment of each metal.

Since ores, even after mechanical separation, rarely contain but one valuable metal, impure metal-bearing materials in important quantity are by-products of many smelters. A fortunate circumstance exists, therefore, where units capable of treating diverse products are located within a limited area and can function as an interlocking system.

Copper Smelting.[21] The process and equipment used in the smelting and refining of copper from sulfide ores has become more standardized than those for lead and zinc. Recovery is generally high, being 95 percent or better of the copper in the ore or concentrates. Concentrates usually range in grade from 12 to 35 percent copper, and sulfide ores containing less than 5 percent copper are seldom smelted directly. Non-valuable constituents of the ore are largely iron sulfide and nonmetallic minerals.

The first step in copper smelting usually consists of roasting the ore in a controlled stream of air with the object of removing a part of the sulfur as gaseous sulfur dioxide.

Smelting is essentially a two stage process. The ore, mainly as finely pulverized concentrates, sometimes partly roasted, is fed, along with suitable fluxing material, preferably in the form of ore containing copper, gold or silver, directly to the hearth of a reverberatory furnace. The copper reverberatory comprises an elongated (100 to 130 feet) rectangular (30 feet or more wide) refractory-lined vessel holding some 3 feet of molten material and is topped by a shallow refractory arch. Fuel, in the form of gas, oil, or pulverized coal, mixed with air is burned in the space above the charge. The incandescent gases, without reacting chemically with the charge, provide the heat necessary to bring about its complete fusion.

At fusion temperature copper has a strong affinity for sulfur and a weak affinity for oxygen by comparison with other basic elements in the charge. The sulfur left over from combination with copper reacts principally with iron and the sulfur copper-iron mixture, called matte, settles to the bottom by reason of its high density, leaving the other charge constituents including excess iron as a superincumbent layer of slag. If the charge has been properly proportioned the gangue is converted into a

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[21] Pyne, Francis R., The metallurgy of copper, in Liddell, D. M., Handbook of nonferrous metallurgy, 2d ed., vol. 2, pp. 227-274, 1945.
Newton, J., and Wilson, C. L., Metallurgy of copper, 518 pp., New York, John Wiley & Sons, Inc., 1942.
Newton, Joseph, Introduction to metallurgy, 527 pp., 1938.

practically valueless slag and the matte comprises a small amount of high grade material containing most of the copper and precious metals in the ore along with some of the other metals.

Gravity segregation of matte and slag takes place during the leisurely flow of the molten charge from the feed toward the tapping end of the furnace. Slag is tapped from points near the top and matte from points near the base of the stratified charge.

The second step in the reduction to metallic copper is based on the reactions which occur when atmospheric oxygen is brought into intimate contact with the molten matte. The matte is delivered in large ladles from the reverberatory furnace and poured into the conical mouth of a refractory-lined vessel called a converter. This vessel is suspended on an axis and provided with a tilting mechanism for use in discharging its contents.

Near the base of the vessel air is introduced in thin streams through multiple openings called tuyeres. Converting consists in blowing the charge until a large fraction of the sulfur is driven off as gaseous sulfur dioxide and the iron is oxidized and slagged with added silica. At this stage the slag is poured off leaving a much enriched copper-sulfur mixture called white metal which, by a second stage of blowing is reduced to impure or blister copper. This is cast into convenient forms and shipped for further purification, usually by electrolytic methods. The precious metals are recovered during electrolytic refining.

The oxidizing reactions during converting provide the heat necessary to keep the charge molten. The converter slag contains appreciable amounts of copper and is generally returned to the reverberatory furnace.

Lead Smelting.[22] The physical chemistry of lead and its compounds allows a rather wide choice of tactics for recovering it from ores.

(1) Lead sulfide can be directly reduced by metallic iron.
(2) Lead oxide can be reduced by carbon or carbon monoxide.
(3) The reaction between lead sulfide and lead sulfate (or oxide) results in a double decomposition forming lead and sulfur-dioxide gas.

All of these reactions take place to a greater or lesser extent in smelting lead sulfide ores by any method, although one of the reactions may be intentionally emphasized to gain a desired end such as the separation of copper as copper-lead matte in a lead ore high in copper.

Currently the most popular and important smelting method in this country relies principally on the reduction by carbon. Usually this is a three stage process involving roasting to eliminate sulfur, sintering to eliminate further sulfur and agglomerate the fine ore particles, and smelting with suitable flux in a blast furnace.

The recovery of lead as bullion containing the precious metals is high, being 95 percent or more of the lead in the blast furnace charge. The principal losses of lead occur as vaporization of the oxides during roasting and sintering. This loss is usually recovered in the form of flue dust, and as lead silicate in the blast furnace slag. Lead bullion is refined and its precious metals extracted usually by a sequence of fire refining methods.

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[22] Bowman, R. G., Lead, in Liddell, D. M., Handbook of nonferrous metallurgy, 2d ed., vol. 2, pp. 144-215, 1945.
Newton, Joseph, Introduction to metallurgy, 537 pp., 1938.

The modern lead blast furnace is fairly standardized and consists essentially of a squat vertical shaft of iron, steel and masonry weighting some 100 tons. In horizontal section the furnace is rectangular, some 36 to 63 inches wide by 160 to 270 inches long. Furnaces average 20 feet in height between tap hole and charging floor and have capacities of 150 to 425 tons of charge per day.

Tuyeres for admitting the air blast are located along the sides but not the ends of the furnace. The smelting zone is lined with steel water jackets.

A typical charge for a lead blast furnace consists of 75 percent sinter with 3 percent sulfur, 10 to 12 percent coke and the remainder fluxing ore with sufficient silica to form a slag containing 20 to 35 percent silica. Lead forms 10 to 50 percent of the charge and when high grade ore is being fed molten lead is tapped continuously by a siphon arrangement.

The Extraction of Zinc.[23] The physical chemistry of zinc in association with its ores restricts its efficient practical extraction to two fundamental methods: the electrolytic method and the pyrometallurgical method of which there are several variations all based on the principle of distillation.

As a preparatory step for either method zinc in combination with sulfur must be roasted in a stream of air until the zinc is essentially all in oxide form.

Once the zinc is available as oxide (some sulfate is needed) it may be taken into water solution by the hydrometallurgical process of leaching with sulfuric acid and the zinc extracted in electrolytic cells. More will be said of this under a subsequent heading.

The pyrometallurgical processes depend on the reduction of zinc oxide by carbon, or more specifically by carbon-bearing reducing gases such as carbon monoxide, followed by the volatilization of zinc as vapor. The low boiling point of zinc (905°C) allows the distillation to take place at a temperature below the fusion point of the associated gangue, a circumstance used to advantage in the distillation processes. Zinc present in molten slag also can be reduced and volatalized by blowing a slag charge with reducing gases. This type of process is known as "slag fuming" and is used principally in recovering zinc from lead blast furnace slags. Similar tactics have been used experimentally to recover zinc from copper matte and slag.[24]

The form in which zinc may be recovered by pyrometallurgical processes depends on the kind of furnace and collecting equipment used and to a material degree on the concentration of zinc vapor with respect to the other gases evolved by the furnace.

Where the zinc vapor amounts to approximately half of the total gas volume it is usually possible to recover it as liquid metal in conventional condensers. Where the zinc vapor concentration is low specialized equipment (see *Electrothermic Process)* is necessary to recover it as metal. Usually it is more expedient to burn the vapor to zinc oxide and recover it as such. Certain processes (see *Waelz Process)* depend on the heat

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[23] Ingalls, W. R., Pyrometallurgy of zinc, in Liddell, D. M., Handbook of nonferrous metallurgy, 2d ed., vol. 2, pp. 444-472, 1945.

Bray, J. L., Non-ferrous production metallurgy, pp. 352-396, New York, John Wiley & Sons, Inc., 1941.

Laist, Frederick, Caples, Russel B., and Wever, Guy T., The electrolytic zinc process, in Liddell, D. M., Handbook of nonferrous metallurgy, 2d ed., vol. 2, pp. 379-443, 1945.

[24] Ralston, O. C., Fowler, M. G., and Kuzell, C. R., Recovering zinc from copper smelter products: Eng. and Min. Jour., vol. 136, no. 4, April 1935, pp. 167-169.

given off by the burning zinc vapor and are incapable of producing metal directly.

One vital problem in all zinc pyrometallurgy is that of providing access for the reducing agent to each molecule of zinc and also of providing free paths by which the resulting zinc molecule may find its way from the charge to the collecting device. The particles of the charge meanwhile must have certain mechanical properties, such as strength, to meet the conditions imposed by the particular process.

This problem is met in practice by various methods of treating the calcines from the roaster preparatory to charging the distillation furnace.

Solid carbonaceous fuels (coke, coal) are almost universally used as sources of reducing material. Calcines are more or less thoroughly mixed with pulverized fuel amounting to 10 percent or more of the charge. This mixture is then processed either by briquetting or sintering to give it the necessary permeability and strength for efficient distillation. The most common modern methods of roasting and sintering are described as follows.

Roasting today presents no great difficulties and is most frequently carried on in the McDougal type furnace comprising a vertical cylindrical element, some 20 feet in diameter, within which are a number of horizontal hearths. Concentrates are fed to the top hearth from whence they are worked downward over a maze-like course by a combination of gravity fall and spiral motion imparted by slowly rotating rabbling arms fixed to a central shaft. Controlled amounts of air are admitted and caused to move generally in an upward or countercurrent direction. A certain fraction and sometimes all of the necessary heat is provided by the burning sulfides in the charge.

A comparatively new and important variation of hearth roasting is known as flash-roasting. Dried concentrates are blown into the furnace from which several hearths have been removed and the sulfides burn during their brief interval of suspension in a manner similar to that of pulverized coal. The capacity of a hearth-type furnace may be approximately doubled by this procedure (say from 50 to 100 tons per day).

Sintering is extensively carried out with the Dwight-Lloyd sintering machine, which functions like an endless belt travelling horizontally across a suction box and returning beneath it. The calcined concentrate mixture is spread in a uniform layer on the porous pallets of the machine and the top surface is ignited by an oil flame. As the bed moves the reaction (or burning) is self-propagated into the bed until, near the discharge end, the reaction is complete and the sinter is dumped from the pallets as cakes.

Losses of zinc in pyrometallurgical processes are partly in the final residue and partly as escaping dust or vapor. Over-all recovery may be over 90 percent. Since most furnace operations such as roasting, sintering, and distillation are accompanied by a greater or lesser evolution of dust expensive and elaborate dust catching installations are common to all smelting. Only typical equipment will be described herein.

Cottrell precipitators, functioning on electrostatic principles, are particularly well suited to operation over a wide range of temperatures and with virtually any collecting efficiency called for. Cyclone collectors, operating on the principle of the centrifuge have a lower collecting efficiency than Cottrell machines but are also lower in first cost. Bag houses comprising a multiplicity of cloth filtering bags must be used under relatively cool, non-corrosive conditions. The simplest dust catcher is the settling chamber, in effect merely an enlargement of the gas-duct. These and other gas cleaning devices may be employed together in one smelter.

Once an adequate supply of ore has been established the choice of a zinc extracting process depends not only on the accessibility of other supplies, including fuel and power, but also on the foreign constituents in the ore, its grade, and on the kind of metal and by-products that can be marketed with greatest profit. Some of the limitations of processes will be mentioned subsequently but a word should be said here of the grades and uses of zinc.

Standard specifications for slab zinc have six classifications showing the maximum limitations of the common impurities lead, iron, and cadmium. In general the higher grades bring some price premium, but in consideration of the fact that the principal local use for zinc is in galvanizing, which requires the lowest grade, such a premium might not be realized.

Galvanizing or ''Prime Western'' zinc must have 98 percent zinc and not more than 1.6 percent lead.

''Brass special'' zinc must have 98.7 percent zinc and not more than 0.6 percent lead.

''Special high grade'' zinc must assay 99.99 percent zinc and is used in a limited class of alloys. Most electrolytic zinc is of this grade.

Batch Retort Process. This process, one of the older methods for the production of zinc from ores persists in this country only by virtue of considerable existing installations. A number of retorts, small (7 inches by 4 to 6 feet) cylindrical ceramic bodies of a composition suited to resist the attack of particular ores occupy parallel, almost horizontal positions, in oil or gas fired furnaces. Condensers made of similar material but of slightly smaller size fit the open ends of the retorts and extend from the external walls of the furnace. The ore and reducing agent, prepared somewhat as outlined above, but usually in less exacting manner is fed semi-mechanically in cycles of 24 hours. Spelter (impure zinc) is withdrawn at intervals of one to four times during the distilling cycle. Recovery is between 85 and 92 percent.

Continuous Vertical Retort Process.[25] Where the necessary heat for reduction and vaporization must be introduced through an external shell, as in any retort process, one cross-sectional dimension must be kept relatively small. Major problems in adapting the retort process to continuous operation were to overcome the heat transfer difficulties and the tendency of the charge to hang up rather than flow evenly downward through narrow sections. These problems were solved in the New Jersey Zinc Company's process. By increasing the section to 1 by 6 feet and the heated length to 25 feet and by briquetting the feed with appropirate binders, both adequate heat transfer and even flow were achieved. Retorts are made in rectangular sections laid up like bricks and of highly conductive silicon carbide.

Condensers consist of an inclined part connected to the retort and a sump section with baffles to increase the path of flow. Recovery of marketable zinc is about 92 percent. Each retort has an output of about 4 tons of zinc per day.

[25] Bunce, E. H., and Handwerk, E. C., New Jersey Zinc Company vertical retort process: Am. Inst. Min. Met. Eng. Trans. vol. 121, pp. 427-434, 1936.

The principal advantages of the process lie in its complete mechanization, high recovery, and thermal efficiency, long retort life (3 to 5 years), and ease of control because of the uniformity of operation under steady-flow conditions.

The first plant, at Palmerton, Pennsylvania, went into commercial production in 1929.

Electrothermic Process.[26] The limitations of heat transfer through an external shell are nicely avoided in the St. Joseph Lead Company's electrothermic process. By adding an equal portion of electrically conductive coke to the carefully prepared and sintered ore the charge itself allows the passage of a large current, thus affording sufficient heat to conduct the distillation.

The electrothermic furnace is a lined cylindrical shell built up of ring-shaped elements to a height of 37 feet and having a diameter of 57 inches. Near the top and also near the base of the shaft and protruding into it a few inches are groups of three equally-spaced graphite electrodes. Near the center of the shaft is a ring-shaped aperture for collecting the vapor and gases. The charge, some 40 tons per day, is fed automatically at the top of the shaft and passes downward by gravity. Current requirements are about 2500 kilowatt-hours per ton of zinc.

A novel condensing system is used with the furnace. The condenser is built in the form of a U-tube with its outgoing arm connected to a vacuum pump. Gases and vapors evolved from the charge are forced by suction to bubble through the molten bath of zinc in the condenser. Close temperature control of the bath results in a fractional distillation effect and allows the direct production of 99.97 percent zinc.

The original installation at Josephtown, Pennsylvania, was used for the production of zinc oxide. The Weaton-Najarian condenser described above was patented in 1937. Further improvements were patented in 1942.

Waelz Process.[27] This process, in which the furnace is an ordinary rotary kiln, is particularly suited to the removal of the more volatile metals and compounds from complex ore and their collection as a fume. Since the products—either the fume or the clinker—are rarely marketable as finished products, the process is one of concentration. Where ore dressing methods are capable of performing this function efficiently consideration of the Waelz process is scarcely warranted. Where ore dressing fails to make satisfactory separations or where a heterogeneous variety of complex ores or concentrates is to be treated, the versatility and comparative cheapness of the Waelz process are worthy of investigation.

The feed to the Waelz kiln seldom requires the sintering treatment necessary in other distilling processes. Partial roasting and thorough mixing with carbonaceous fuel (10-30 percent of the charge) are necessary. The kiln can be fed a wet feed of particles ranging up to $\frac{1}{8}$ inch in size and up to 18 percent sulfur.

The kiln consists of a long refractory-lined steel cylinder set on a slope of 1 to 6 percent and rotating at approximately one revolution per minute on steel rollers. Kilns vary in size from 40 by 6 feet to 160 by 12

[26] Weaton, G. F., St. Joseph Lead Company's electrothermic zinc-smelting process: Am. Inst. Min. Met. Eng. Trans., vol. 121, pp. 599-609, 1936.
Ingalls, W. R., Pyrometallurgy of zinc, in Liddell, D. M., Handbook of nonferrous metallurgy, 2d ed., vol. 2, pp. 444-472, 1945.
[27] Harris, W. E., Waelz process: Am. Inst. Min. Met. Eng. Trans., vol. 121, pp. 702-720, 1936.

feet. A kiln of the larger size in upper Silesia had a capacity of 160 tons per day on an ore containing 12 to 15 percent zinc. The extraction was 95 percent.

Action within the kiln is intense and is sustained for a period of some 2 hours on each particle of feed. The reaction is one of simultaneous reduction, volatilization and oxidation. The fume so formed passes countercurrent to the flow of ore and by virtue of the extremely fine particle size of the metallic oxides (one micron or less) it is usually possible to precipitate the ordinary furnace dusts and the metallic fume independently. The net input of heat is small, and some ore mixtures are self-burning.

If the feed contains lead most of it goes into the fume. By mixing the fume with 1 to 10 percent coke and a small quantity of common salt the mixture can be de-leaded by passage through a small Waelz kiln.

Certain complex zinc-copper-lead ores do not give satisfactory recovery by differential flotation. In such cases it may be possible to make a bulk concentrate with satisfactory recovery of the valuable metals. The Waelz process could be employed to make a separation of zinc oxide and lead oxide products with a sinter containing the copper and precious metals. The improvement in smelter returns would have to be sufficient to cover the additional treatment costs.

Electrolytic Process.[28] Developments of this process have made it suitable for the treatment of almost any kind of zinc ore. Where power is cheap the process is able to compete with distillation processes.

The process may be divided into three steps: (1) preparation of the ore by careful roasting, (2) leaching of the ore and purification of the resulting zinc sulfate solution, and (3) electrolysis of the solution to produce metallic zinc and regenerate the leaching solution.

The roasting must be conducted with particular care to avoid the formation of insoluble zinc-iron compounds called ferrites. Where the iron is in intimate contact with the zinc of the ore the formation of ferrites cannot entirely be avoided and this condition causes the principal loss of zinc in the process.

The leaching process is usually carried out in large lead-lined tanks in which the roasted ore is mixed with dilute sulfuric acid and agitated with compressed air. The solution and solids are then separated first by settling and finally by filtration and the clear solution is treated for removal of impurities held in solution.

The principal impurities, copper and cadmium, are precipitated from solution by the addition of zinc dust. Further steps must be taken in certain cases. Solids are again separated from the solution by filtration and the solution is pumped to the electrolytic cells.

Cells comprise rectangular tanks usually of wood or mastic-lined concrete and of various sizes, arranged in compact groups. The electrodes (pure lead anodes and pure aluminum cathodes) are in the form of sheets arranged in parallel groups suspended vertically in the cells with a spacing of about 4 inches. Current is conducted by heavy copper bus-bars and in sufficient quantity to give an average potential drop of about 3.4 volts per cell, which represents an average current consumption of some 30 amperes per square foot of anode area.

Direct current is provided by rectifiers or motor generators, which convert the incoming alternating current from the power lines. Approxi-

[28] Laist, Caples, and Wever, op. cit.

mately 3600 kilowatt-hours of power are required to produce one ton of zinc on a 100 ton per day basis. This figure includes power for auxiliary equipment and may be compared with the total smelter power requirements of 3258 kilowatt-hours for the Josephtown electrothermic plant producing 100 tons of zinc per day from 50 to 55 percent zinc concentrates. Over-all recoveries by these two processes are evidently comparable.

Reflux Fractional Distillation of Zinc.[29] The spelter resulting from all simple distillation processes for the recovery of zinc is likely to contain some lead, cadium and iron as well as other elements commonly associated with zinc ore. Since "special high grade" zinc (99.99 percent) commands a premium, the extra expense of producing such a grade may be economically justifiable. Most electrolytic zinc is of this quality.

By application of the same principles of reflux distillation as are widely used in the petroleum and chemical industries the New Jersey Zinc Company has perfected a process for the refining of zinc. Molten spelter from the condensers of continuous retorts is transferred to the melting pots of the reflux units. Here the metal is revaporized and the vapors first enter the lead column where they pass upward through a multiplicity of trays and come into intimate contact with a downward current of molten metal largely in the form of small drops.

The temperature gradient within the column (cooler at the top) is such that the rising vapor becomes continuously enriched in cadmium and zinc and impoverished in lead. Conversely the down dripping liquid becomes enriched in lead and is collected as such at the bottom.

The residual vapors from the lead column are passed to the cadmium column where a similar separation takes place. Here pure zinc is condensed and cadmium passes over as vapor and dust. Each unit operates continuously and has a capacity of 15 tons daily.

The Capital Costs of Metallurgical Plants. So many factors are involved in the costs of metallurgical plants that the figures to be given should be regarded merely as rough guides.

The Howe Sound Flotation plant for the treatment of 1300 tons per day of a complex copper-zinc-gold ore is reported [30] to have cost in 1938, $592 per ton daily capacity. Machinery accounted for 35 percent of this cost.

The Demonstration mill in the Philippine Islands, a 350-ton flotation-cyanidation mill for gold ore cost in 1934 [31] $890 per ton daily capacity. Machinery accounted for 44 percent of this cost.

One thousand dollars is often assumed as the approximate per ton daily capacity cost of a small (less than 100 tons) flotation plant. At the present labor scales 70 percent of costs may be for labor and supplies exclusive of machinery.

The cost of an electrolytic zinc refinery is estimated [32] to range between $30,000 and $40,000 per ton daily capacity, depending on size and circumstances.

The cost of an electrothermic zinc plant of 100 tons daily capacity would probably exceed slightly $40,000 per ton daily capacity.

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[29] Ingalls, W. R., op. cit., pp. 466-467.
[30] Taggart, A. F., op. cit., sec. 20, pp. 75-79.
[31] Taggart, A. F., op. cit., sec. 20, pp. 75-79.
[32] Laist, Caples, and Wever, op. cit., pp. 434-435.

PART THREE

TABULATION OF COPPER PROPERTIES TO ACCOMPANY ECONOMIC MINERAL MAP OF CALIFORNIA NO. 6 (COPPER)

TABULATION OF COPPER DEPOSITS OF CALIFORNIA *

By John H. Eric **

OUTLINE OF REPORT

ILLUSTRATIONS

INTRODUCTION

California occupies seventh place among the copper-producing states (eighth including Alaska), and produced 1.86 percent of the total copper recorded for the United States during the period 1845-1945, as shown in table 1.

* Published by permission of the Director, U. S. Geological Survey. Manuscript submitted for publication July 1948.
** Geologist, U. S. Geological Survey.

Table 1. Copper production of principal states (including Alaska), 1845-1945. (Minerals Yearbook, U. S. Bureau of Mines.)

State	Copper produced (short tons)			
	Mine production		1845-1945 smelter output[1]	
	Period	Total quantity	Total quantity	Percent of total
Arizona	1860–1945	10,888,869	10,856,068	33.48
Montana	1862–1945	6,519,872	6,567,879	20.26
Utah	1864–1945	4,786,157	4,839,468	14.93
Michigan		[2]	4,803,088	14.81
Nevada	1859–1945	1,734,052	1,722,168	5.31
New Mexico	1848–1945	1,300,008	1,295,543	4.00
Alaska	1880–1945	685,864	676,856	2.09
California	1848–1945	621,584	603,682	1.86
Colorado	1858–1945	248,957	276,640	0.85
Tennessee		[2]	[3]259,508	[3]0.80
Idaho	1863–1945	106,749	100,698	0.31
Washington	1860–1945	74,399	76,596	0.24
Wyoming	1867–1945	16,325	15,871	0.05
Oregon	1852–1945	12,336	11,669	0.04
Undistributed		[2]	[4]316,019	[4]0.97
Total U. S. A.			32,421,753	100.00

[1] Mine figures used for 1945; smelter output not compiled by states of origin after 1944.
[2] Not available.
[3] Approximate production through 1928. Figures for 1929-45 confidential and included under "Undistributed."
[4] Includes Tennessee for 1929-45.

Table 2. Relation of California copper production to that of the United States, 1862-1945[1] in short tons (Compiled by Alfred L. Ransome, U. S. Bureau of Mines, Metal Economics Branch, from Mineral Resources and Minerals Yearbook.)

Year	United States	California	Percent of U. S. A.
1862	10,580	1,300	12.28
1863	9,520	1,100	11.55
1864	8,969	2,400	26.78
1865	9,520	1,800	18.91
1866	9,968	1,300	13.04
1867	11,200	700	6.25
1868	12,992	650	5.00
1869	14,000	288	2.06
1870	14,112	28	0.20
1871	14,560	300	2.06
1872	14,000	175	1.25
1873	17,360	225	1.30
1874	19,600	160	0.82
1875	20,160	----------	----------
1876	21,280	----------	----------
1877	23,520	250	1.06
1878	24,080	200	0.83
1879	25,760	256	0.99
1880	30,240	500	1.65
1881	35,840	250	0.70
1882	45,323	413	0.91
1883	57,763	800	1.38
1884	72,473	438	0.60
1885	82,938	235	0.28
1886	78,368	215	0.27
1887	90,460	800	0.88
1888	113,181	785	0.69
1889	113,388	76	0.07
1890	129,882	12	0.01
1891	142,061	1,699	1.20
1892	172,499	1,490	0.86
1893	164,677	120	0.07
1894	177,094	60	0.03
1895	190,307	109	0.06
1896	230,031	345	0.15
1897	247,039	5,994	2.43
1898	263,256	8,463	3.21
1899	284,333	13,111	4.61
1900	303,059	14,256	4.70
1901	301,036	16,834	5.59
1902	329,754	12,519	3.80
1903	349,022	8,888	2.55
1904	406,269	14,981	3.69
1905	450,954	8,349	1.85
1906	458,486	14,363	3.37
1907	423,576	14,264	3.37
1908	478,420	19,388	4.05
1909	563,261	28,644	5.09
1910	544,119	24,350	4.48
1911	557,382	18,158	3.26
1912	624,047	16,726	2.68
1913	617,785	17,288	2.80
1914	574,216	15,254	2.66
1915	744,036	20,376	2.74
1916	1,002,938	27,949	2.79
1917	947,717	24,077	2.54
1918	955,011	23,837	2.50
1919	606,167	10,866	1.79
1920	612,275	6,313	1.03
1921	233,095	5,872	2.52
1922	482,292	11,270	2.34
1923	738,870	14,159	1.92
1924	803,083	26,054	3.24
1925	839,059	23,432	2.79
1926	862,638	16,733	1.94
1927	824,980	13,567	1.64
1928	904,898	12,575	1.39

Table 2. Relation of California copper production to that of the United States, 1862-1945[1] *in short tons (Compiled by Alfred L. Ransome, U. S. Bureau of Mines, Metal Economics Branch, from Mineral Resources and Minerals Yearbook)—Continued.*

Year	United States	California	Percent of U. S. A.
1929	997,555	16,609	1.66
1930	705,074	13,643	1.93
1931	528,875	6,466	1.22
1932	238,111	709	0.30
1933	190,643	495	0.26
1934	237,405	285	0.12
1935	380,498	977	0.26
1936	614,515	4,381	0.71
1937	841,998	5,251	0.62
1938	557,763	806	0.14
1939	728,320	4,180	0.57
1940	878,086	6,438	0.73
1941	958,149	3,943	0.41
1942	1,080,061	1,058	0.10
1943	1,090,818	8,762	0.80
1944	972,549	12,721	1.31
1945	772,894	6,473	0.84

[1] Production data for the United States are smelter production from 1862 to 1905, inclusive, and mine production (in terms of recoverable metal) from 1906; data for California are smelter production from California ores from 1862 to 1903, inclusive, and mine production (in terms of recoverable metal) from 1904.

The relation of California yearly production to that of the rest of the United States is shown in table 2. In 1864 California produced 26.78 percent of the total for the country in that year, but in 1890 the State produced only 0.01 percent. Except for 1944, California's yearly copper production since 1932 has been less than one percent of the national annual total.

DISTRIBUTION OF COPPER IN CALIFORNIA

Of the copper produced in California 92 percent has come from three areas which are, in order of production:

		Percent of total State production through 1946
(1) Shasta County		54
(2) Plumas County		26
(3) Foothill belt counties:[1]		12
Calaveras County	10 percent	
Other counties	2 percent	
Total for the three areas		92
All other areas		8
Total		100

Figure 1 shows the same facts graphically.

Table 3 shows recorded production of the 14 principal copper-producing counties of the State.

These counties have produced 97 percent of the State total, and 90 percent has come from the first three counties, as shown in figure 1 and table 4.

[1] The Foothill belt extends through parts of the following counties: Butte, Yuba, Nevada, Placer, El Dorado, Amador, Calaveras, Tuolumne, Mariposa, Madera, and Fresno. A few deposits are also reported from extreme eastern Stanislaus and Merced Counties. Precise production figures for the Foothill belt are not available, but doubtless they are only slightly below the county figures.

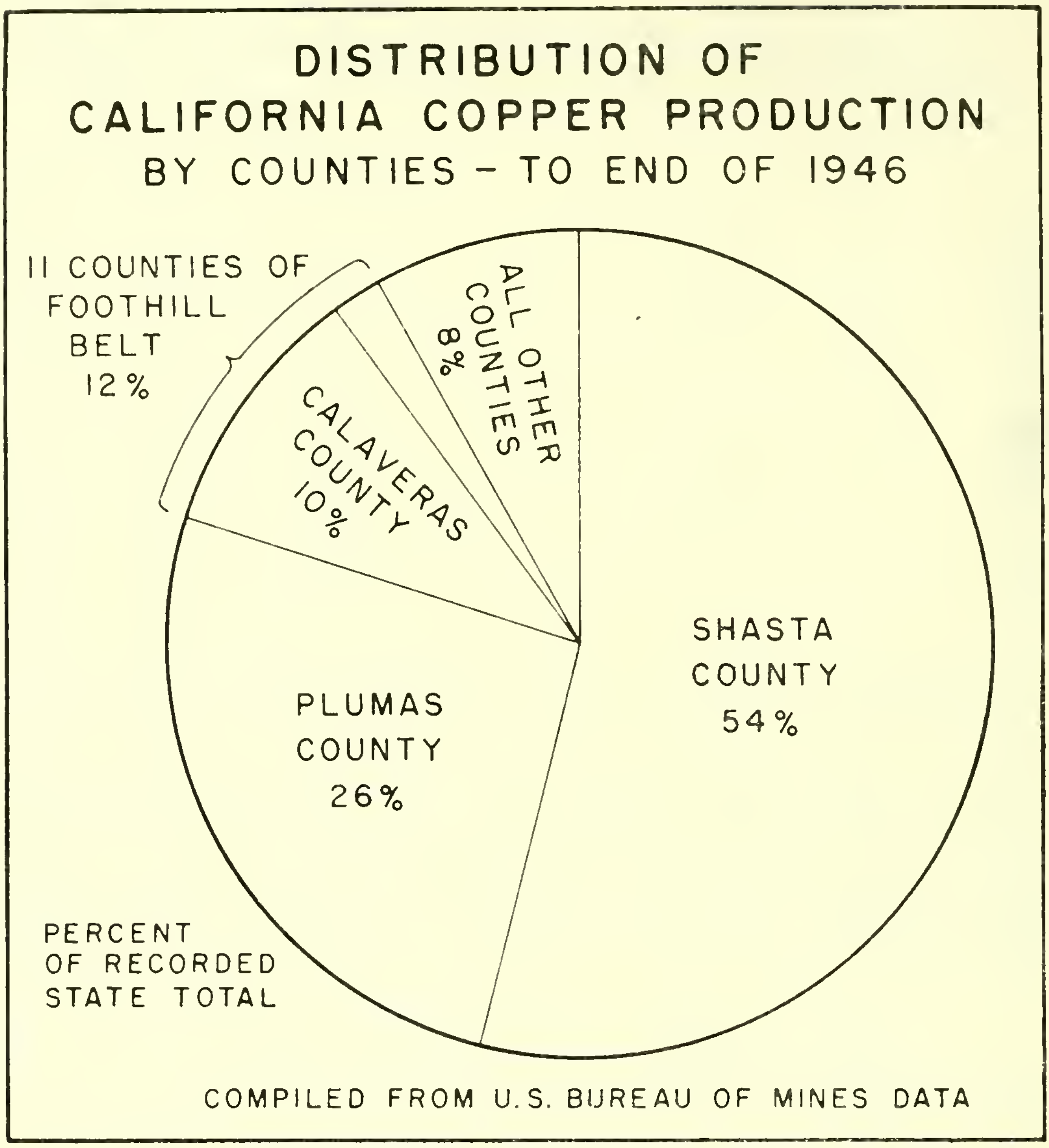

Fig. 1. Chart showing distribution, by counties, of copper production in California.

Table 3. Mine production of copper in terms of recovered metal, from California counties that produced more than 1,000,000 pounds during the period 1904-1946, inclusive.[1]

(Compiled by Alfred L. Ransome, U. S. Bureau of Mines, Metal Economics Branch)

County	Pounds of copper	County	Pounds of copper
1. Shasta	523,904,275	9. Placer	5,469,654
2. Plumas	324,834,697	10. Fresno	3,975,684
3. Calaveras	119,581,890	11. Madera	2,615,088
4. Siskiyou	31,829,498	12. Mariposa	1,717,787
5. San Bernardino	11,467,804	13. Nevada	1,107,971
6. Trinity	8,650,224	14. Butte	1,021,150
7. Inyo	6,856,334		
8. Amador	5,656,187	Total	1,048,688,243

Total California:

1904-1946	1,052,561,715
1848-1946	[2]1,251,648,000

[1] The first satisfactory annual canvass of mine production was made in 1904. A major part of the 199,086,285 pounds of copper produced in California during the period 1848 to 1903, inclusive, was mined subsequent to 1893. According to published records of the California State Division of Mines (Bulletin No. 130, 1945) 171,442,192 pounds of copper was produced from the 14 counties listed in the table from 1894 to 1903, inclusive, principally from Shasta (153,394,110 pounds), Calaveras (8,118,701 pounds), Fresno (4,159,672 pounds), San Bernardino (3,738,758 pounds), and Madera (663,030 pounds) Counties.

[2] Records of the Bureau of Mines and the California State Division of Mines show that Kern County produced more than 1,000,000 pounds of copper, of which only 431,482 pounds has been recorded by the Bureau since 1903. Published accounts of copper in California indicate that the 1,000,000-pound mark has been reached by Del Norte County, largely from sizeable production in the 1860's for which figures are not available.

Table 4. Distribution of copper production in California, 1848-1946, inclusive. Compiled from U. S. Bureau of Mines and California Division of Mines data.

Localty		Percent of recorded State total
14 principal copper-producing counties, production more than 1,000,000 pounds[1]: Shasta, Plumas, Calaveras, Siskiyou, San Bernardino, Fresno, Inyo, Placer, Trinity, Madera, Amador, Mariposa, Nevada, and Butte		97
3 principal counties: Shasta, Plumas, Calaveras		90
6 principal mines of State:		
Iron Mountain (including Hornet), Mammoth	Shasta County	
Walker, Engels	Plumas County	79
Penn, Keystone-Union	Calaveras County	
Shasta County:		54
2 principal mines of State: Iron Mountain (including Hornet), Mammoth	Shasta County	42
Plumas County:		26
11 counties of Foothill belt: Calaveras, Fresno, Placer, Madera, Amador, Mariposa, Nevada, Butte, El Dorado, Tuolumne, Yuba		12
Principal county of Foothill belt: Calaveras		10

[1] Kern County and Del Norte County production, although indicated to be more than 1,000,000 pounds, are not included as data are not available.

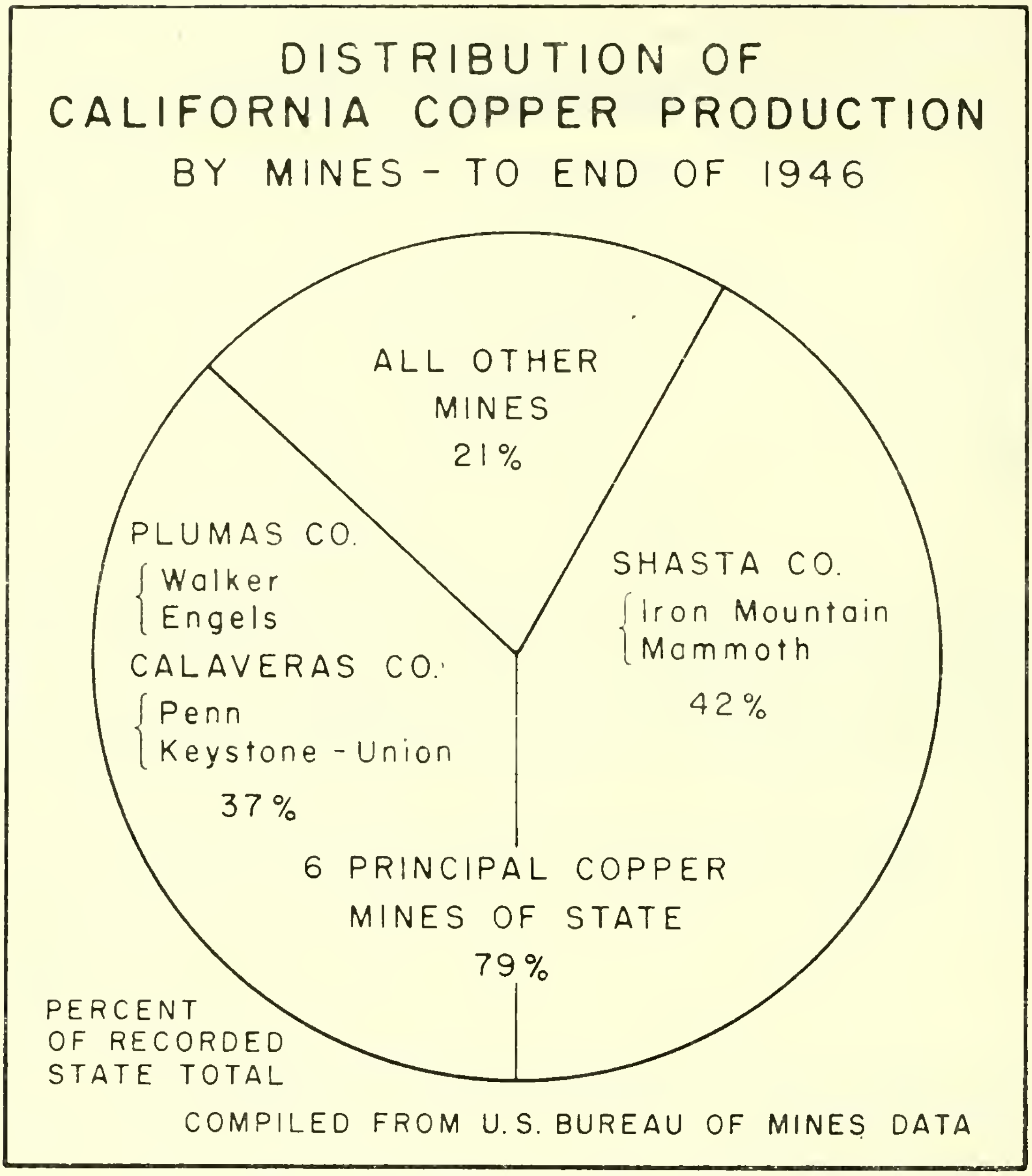

FIG. 2. Chart showing recorded distribution, by mines, of copper production in California.

Table 5. California mines that have produced more than 1,000,000 pounds of copper (to end of 1945). (Prepared chiefly from information made available by the U. S. Bureau of Mines, Metal Economics Branch, San Francisco office.)

Amador
9. Copper Hill
30. Newton

Butte
2. Big Bend

Calaveras
18. Keystone-Union
34. Napoleon
18. North Keystone
37. Penn
39. Quail Hill

Fresno
7. Copper King
8. Fresno

Inyo
178. Pine Creek

Madera
15. Daulton

Nevada
55. Spenceville

Placer
13. Dairy Farm
36. Valley View

Plumas
28. Engels
66. Superior
70. Walker

San Bernardino
83. Copper World

Shasta
4. Afterthought
11. Balaklala
23. Bully Hill
75. Hornet
81. Iron Mountain
88. Keystone
100. Mammoth
132. Rising Star
141. Shasta King
154. Sutro

Siskiyou
8. Blue Ledge
31. Gray Eagle

Trinity
21. Island Mountain

The tendency of large deposits to occur in definite, restricted areas is shown by the fact that over three-quarters (79 percent) of the State's recorded copper production has come from six mines: Iron Mountain and Mammoth in Shasta County, Walker and Engels in Plumas County, and Penn and Keystone-Union in Calaveras County; in fact, almost half (42 percent) has come from the Iron Mountain and Mammoth mines, as shown in figure 2.

It seems likely, therefore, that the majority of new discoveries will be made in the same general regions. This is not to say that all other areas should be neglected: millions of pounds has come from districts outside the principal ones; but the chances of finding large new deposits are best in the Shasta, Plumas, and Foothill belts, and particularly in certain parts of these belts.

The 32 principal copper-producing mines are listed in table 5.

Seventy-seven less important copper-producing mines are shown in table 6.

In addition to these sources, there are hundreds of reported occurrences widely scattered throughout the State, as shown by table 7.

This list is incomplete, as there are probably many unreported copper prospects in the State.

Only 8 of the 58 counties, so far as known, have had no copper deposits reported in them; these are: Kings, San Francisco, San Joaquin, San Mateo, Santa Cruz, Solano, Sutter, and Yolo. Even in these counties, however, copper minerals doubtless are sparsely present in the rocks and soil. In other words copper, though not abundant, is extremely widespread in California.

MINERALOGY OF CALIFORNIA COPPER DEPOSITS

The minerals that are possible commercial sources of copper in California are the following[2]:

[2] Pabst, A., Minerals of California: California Div. Mines Bull. 113, 1938.

Name	Chemical composition
1. Azurite	$2CuCO_3.Cu(OH)_2$
2. Bornite	Cu_5FeS_4
3. Chalcocite	Cu_2S
4. Chalcopyrite	$CuFeS_2$
5. Chrysocolla	$CuSiO_3.2H_2O$
6. Covellite	CuS
7. Cubanite	$CuFe_2S_3$
8. Cuprite	Cu_2O
9. Enargite	Cu_3AsS_4
10. Malachite	$CuCO_3.Cu(OH)_2$
11. Native copper	Cu
12. Tenorite (melaconite)	CuO
13. Tetrahedrite	Cu_3SbS_3

Other copper-bearing minerals that have been reported are mainly of scientific interest, and are not commercial sources of copper in California [3]:

Name	Chemical composition
1. Atacamite	$Cu_2Cl(OH)_3$
2. Aurichalcite	$2(Zn,Cu)CO_3.3(Zn,Cu)(OH)_2$
3. Boothite	$CuSO_4.7H_2O$
4. Bournonite	$(Pb,Cu_2)_3Sb_2S_6$
5. Brochantite	$CuSO_4.3Cu(OH)_2$
6. Calciovolborthite	$(Cu,Ca)_3V_2O_8.(Cu,Ca)(OH)_2$
7. Caledonite	$(Pb,Cu)SO_4.(Pb,Cu)(OH)_2$
8. Chalcanthite	$CuSO_4.5H_2O$
9. Crednerite	$CuMn_2O_4$
10. Cuprotungstite	$WO_3.2CuO.H_2O$
11. Linarite	$(Pb,Cu)SO_4.(Pb,Cu)(OH)_2$
12. Liroconite	hydrous arsenate of Al & Cu
13. Partzite	hydrous oxide of Sb, Cu, & other bases
14. Pisanite	$(Fe,Cu)SO_4.7H_2O$
15. Stromeyerite	$(Ag,Cu)_2S$
16. Stylotypite	$3(Cu_2, Ag_2,Fe)S.Sb_2S_3$
17. Turquoise	$H_5(CuOH)[Al(OH)_2]_6(PO_4)_4$
18. Volborthite	$6(Cu,Ba,Ca)O.V_2O_5.15H_2O$

The chief copper ore mineral in the State is chalcopyrite, with bornite and tetrahedrite generally subordinate. In much of the early production, however, chalcocite was the ore mineral, as it is found in the enriched zone just below the gossan. Many of the gossans, some containing malachite, were prospected for gold in the late 1850's and early 1860's, and discovery of the chalcocite zones, in places containing covellite, followed naturally shortly thereafter. With increasing depth the primary sulfides were encountered.

In the copper ores the commonly associated metallic minerals are pyrite or pyrrhotite, and iron-bearing sphalerite. Galena, magnetite, and ilmenite are less usual. Common gangue minerals are quartz, barite, sericite, chlorite, calcite or ankerite, and, in Plumas County, tourmaline. Small amounts of gold and silver generally are associated with the ores.

Cubanite is found in the Walker mine, Plumas County, and enargite occurs in low-temperature deposits of Tertiary age in Alpine County, especially in the Morning Star mine. In the desert regions, where oxidation generally has extended deeper than in other parts of the State, the copper minerals include malachite, azurite, chrysocolla, cuprite, and melaconite. Native copper has been reported from many small deposits, particularly in the Coast Ranges.

[3] Pabst, A., op. cit.

The copper-bearing deposits have yielded mixtures of minerals in varying proportions, depending on the abundance of the minerals and methods of treating the ores. Copper may be the main product, a coproduct, or a byproduct. Of the principal copper deposits of the State, some have been mined mainly for copper, because chalcopyrite is the chief ore mineral. Others have been mined for copper and some other metal, generally zinc: in such deposits the principal ore minerals are usually chalcopyrite and sphalerite, and the ore in most cases contains more zinc than copper. Until comparatively recently these deposits yielded copper alone, and zinc was left behind. Still others have been mined principally for some other metal or metals, and copper is a byproduct. Examples of these three principal kinds of copper-producers have been selected from tables 5 and 6, and are listed below:

Copper chiefly

1. Engels
2. Gray Eagle
3. Island Mountain
4. Keystone-Union
5. Newton
6. North Keystone
7. Walker

Copper coproduct

1. Afterthought (Zn)
2. Big Bend (Zn)
3. Blue Ledge (Zn)
4. Dairy Farm (S, acid, paint)
5. Green Mountain (paint, insect spray, fertilizer and face powder.)
6. Iron Mountain (Zn, acid)
7. Mammoth (Zn)
8. Napoleon (Zn)
9. Penn (Zn)
10. Quail Hill (Zn, Pb, Au)
11. Spenceville (S, acid, paint)

Copper byproduct

1. Blue Moon (Zn)
2. Cerro Gordo (Pb, Ag, Zn)
3. Darwin (Pb, Ag, Zn, W)
4. Empire (Au)
5. Lava Cap (Au)
6. Leviathan (S)
7. Pine Creek (W, Mo)

All of the mines and prospects in the accompanying tabulated list are said to contain copper, but for most of them copper is a byproduct. More than half have as their chief metal gold, silver, lead, zinc, or tungsten. Thus it is possible for a large gold mine, for example, Lava Cap, to have a greater copper production than a copper prospect. The moderately large copper production of Inyo County has come almost exclusively from lead-silver and lead-zinc-silver mines, and from the Pine Creek tungsten mine. Therefore, in the preparation of the tabulated list an attempt has been made, where possible, to show the kind of deposit based on principal metal contained—copper, gold, lead, etc.

GEOLOGY OF CALIFORNIA COPPER DEPOSITS

Almost all the primary copper ore occurs as replacement deposits in igneous and metamorphic rocks.

According to A. R. Kinkel,[4] most of the Shasta County deposits are replacements of sheared siliceous rocks by pyrite, chalcopyrite, and sphalerite. The deposits west of the Sacramento River consist of very large bodies of massive pyrite containing small amounts of chalcopyrite and sphalerite. The ore bodies are essentially flat-lying, pod-shaped masses of pyrite with sharp boundaries. The distribution of chalcopyrite and sphalerite is commonly erratic and not all the massive sulfide constitutes copper ore. Some of the bodies of massive pyrite, such as the Hornet mine of the Mountain Copper Company, are now mined solely for pyrite, which is

[4] Personal communication, 1947.

Table 6. California mines that have produced 100,000 to 1,000,000 pounds of copper (to end of 1944). (Prepared chiefly from information made available by the U. S. Bureau of Mines, Metal Economics Branch, San Francisco office.)

Alameda
1. Alma
2. Leona Heights

Alpine
7. Leviathan
9. Morning Star

Amador
21. Ione Copper

Calaveras
15. Collier
16. Constellation
35. Nassau

Del Norte
2. Alta
28. Salt Lake-California

El Dorado
11. Big Canyon
45. Noonday

Fresno
16. Painter

Humboldt
4. Horse Mountain

Imperial
3. American Girl

Inyo
24. Butte
26. Cardinal
28. Cerro Gordo
38. Columbia No. 2
51. Copper Queen
39, 61, 67, 114, 129, 141, 181, 209. Darwin
104. Gunsight & Noonday
195. Santa Rosa

Kern
26. Greenback

Madera
10. Buchanan
11. Bussolini
17. Felts
32. Pearce & Pearce
33. Probasco

Mariposa
9. Blue Moon
29. Great Northern
30. Green Mountain
43. La Victoria
46. Lone Tree
55. Pocahontas
67. White Rock

Nevada
6. Boss
14. Empire
15. Empress
32. Imperial Paint & Copper
33. Last Chance
34. Lava Cap
39. Mineral Hill
40. Murchie
54. Spanish

Plumas
43. Mohawk
46. Murdock
56. Reward
59. Ruby

Riverside
7. Black Eagle
34. Morning Star
36. Mountaineer

San Bernardino
22. Bagdad-Chase
25. Bell Gilroy
106. Emperor
110. Express
208. Mohawk
244. Piute
257. Revenue
265. Run Over
279. Standard
300. Vontrigger

San Diego
1. Daley
6. Owens

San Luis Obispo
11. Los Osos

Shasta
13. Baxter-Winthrop
48. Early Bird
57. Friday-Lowden
64. Golinsky
66. Graves
68. Greenhorn
90. King Copper
150. Stowell

Siskiyou
39. Kennett Expl. Co.

Stanislaus
1. Selby & Co.

Tuolumne
23. Oak Hill
29. Salambo

used in the manufacture of sulfuric acid. At the southwest end of the ore zone, the Mountain Copper Company mined some disseminated chalcopyrite ore in sercite schist and some quartz-chalcopyrite veins. The deposits east of the Sacramento River are more steeply dipping vein and replacement deposits in schistose rocks and limestone, and in many cases are localized along formational contacts.

The principal copper deposits of Plumas County occur in hydrothermally altered igneous and metamorphic rocks.[5] The Engels ore body is a steeply dipping deposit at the contact of, and within, gabbro and quartz diorite. At one time it was believed that the Engels ore was of magmatic origin,[6] but the deposit is now known to be hydrothermal.[7] The ore bodies at the Superior mine dip about 40° and are in quartz monzonite. Wall-rock alteration includes both tourmalinization and epidotiza-

[5] Knopf, A., The Plumas County copper belt, California, in Copper resources of the world, pp. 241-245, Washington, 16th Internat. Geol. Cong., 1935.

[6] Turner, H. W., and Rogers, A. F., A geologic and microscopic study of a magmatic copper sulphide deposit in Plumas County, California, and its modification by ascending secondary enrichment: Econ. Geology, vol. 9, pp. 359-391, 1914.

[7] Knopf, A., and Anderson, C. A., The Engels copper deposits, California: Econ. Geology, vol. 25, pp. 14-35, 1930.

Table 7. Distribution, by counties, of the 1725 California deposits reported to contain copper. (Prepared chiefly from information made available by the U. S. Bureau of Mines, Metal Economics Branch, San Francisco office.)

County	Number	County	Number
1. San Bernardino	309	26. Butte	11
2. Inyo	235	27. Humboldt	10
3. Shasta	168	28. Mendocino	9
4. Siskiyou	82	29. Tehama	9
5. Plumas	72	30. Sonoma	8
6. Mariposa	70	31. Colusa	7
7. Nevada	60	32. Lassen	7
8. Riverside	57	33. Yuba	7
9. El Dorado	55	34. San Diego	6
10. Calaveras	50	35. Glenn	5
11. Madera	47	36. Merced	5
12. Kern	43	37. Monterey	5
13. Trinity	43	38. Napa	5
14. Amador	39	39. Santa Barbara	5
15. Placer	38	40. Lake	4
16. Del Norte	34	41. San Benito	4
17. Mono	33	42. Santa Clara	4
18. Tuolumne	33	43. Alameda	2
19. Tulare	24	44. Contra Costa	2
20. Fresno	21	45. Orange	2
21. San Luis Obispo	21	46. Marin	1
22. Sierra	21	47. Modoc	1
23. Imperial	18	48. Sacramento	1
24. Los Angeles	18	49. Stanislaus	1
25. Alpine	12	50. Ventura	1

tion. At the Walker mine the steep ore bodies are near the contact between quartz diorite and high-grade metamorphic rocks such as andalusite-garnet rock and cordierite hornfels, in part tourmalinized. The Plumas County deposits contain little or no zinc.

The copper deposits of the Foothill belt, of which the most important part is in Calaveras County (fig. 1), are replacement deposits in hydrothermally altered metamorphic rocks, mainly metavolcanics. The ore bodies generally lie along steep faults within or at the contact of silicified, sericitized, and pyritized zones. Most of the deposits of the Foothill belt contain both chalcopyrite and sphalerite. The commonly associated metallic mineral is pyrite, but where the metamorphism in the country rock is middle- or high-grade, as in Madera County, pyrrhotite is present, in places exceeding pyrite in abundance.

Copper is reported in tactite in a few places, for example at the Lilyama and Pioneer mines in El Dorado County. Although these particular small deposits lie within the Foothill belt, they are geologically and mineralogically quite unlike the Foothill type; minerals present include quartz, calcite, garnet, magnetite, ilmenite, pyrite, and chalcopyrite, which occur within hornfels adjacent to granodiorite. Such copper ore results either from contact metamorphism, or from hydrothermal replacement by chalcopyrite of part of the pyrometasomatic deposit.

Mr. Garniss Curtis [8] has kindly supplied the following preliminary summary of the geology of the two chief copper-producing mines of Alpine County. Country rocks at the Morning Star mine are andesite and dacite flows, agglomerates, and tuffs, of Pliocene age, complexly faulted and, near the mine, apparently dipping south 15° to 45°. Cropping out

[8] Personal communication, 1948.

above the mine and on neighboring ridges are extensive masses of jasper, probably formed by silicification along steep normal faults. Within the silicified zone large bodies of massive enargite and pyrite were discovered. No free gold or silver minerals can be seen, yet assays ran as high as 300 ounces of silver and 1 ounce of gold to the ton. Analyses suggest that the gold and silver are in the enargite. About 3 miles northeast of the Morning Star mine, in Pliocene water-laid dacite tuffs and sediments, is the Leviathan sulfur mine. This deposit, unique in the United States, is similar to sulfur deposits in Japan, and shows evidence of impregnation and replacement of an originally sedimentary sulfur body. Above parts of the main sulfur deposit, which averages about 35 percent sulfur, is a silicified capping, similar to the jasper at the Morning Star mine, containing small amounts of pyrite, bornite, and native sulfur. Oxidation and leaching of this cap rock formed a secondary copper deposit of considerable size, from which early miners extracted ore averaging 30 to 55 percent copper.

TABULATED LIST OF CALIFORNIA COPPER DEPOSITS

Sources of Information and Acknowledgments

The accompanying list of California copper mines, prospects, and occurrences, has been prepared from the literature and from precise annual production figures in the files of the San Francisco office of the U. S. Bureau of Mines, Metal Economics Branch. The production figures were made accessible through the courtesy of C. W. Merrill and A. L. Ransome, and have been generalized so as not to reveal details of production of individual mines.

The compilation began as part of a W. P. A. project in 1936-37, and was continued by Joseph Hollister in 1942, and again in 1942-43 by Hadley R. Bramel of the Department of Mining Engineering, Stanford University. John H. Eric spent the winter of 1945-46 greatly expanding the list and modifying the previous work. This was done as part of a cooperative program between the U. S. Geological Survey and the California State Division of Mines.

Help given by Alfred L. Ransome and H. R. Bramel is gratefully acknowledged as well as that contributed by the personnel of the State Division of Mines, especially Olaf P. Jenkins, Chief, H. H. Symons, Statistician, Miss Elisabeth Egenhoff, Editor, and E. J. Rhodes, Geological Draftsman, who carefully checked the locations of many of the mines before plotting them on the accompanying state map. Much information on the deposits of Shasta County was supplied by W. D. Tillotson of Redding, Attorney at Law. Survey geologists C. W. Merriam, G. R. Heyl, and A. R. Kinkel Jr., have reviewed those parts of the list pertaining to Inyo County, the Foothill belt, and Shasta County, respectively. Tables 1 to 3, inclusive, were prepared by A. L. Ransome, of the Bureau of Mines. The description of the deposits of Alpine County is based on information supplied by Garniss Curtis.

Explanation of the Tabulated List

Class by production:

A. more than 1,000,000 pounds copper
B, 100,000 to 1,000,000 pounds copper
C. 0 to 100,000 pounds copper
D, no known copper production.

Name of deposit refers to the name of a claim, a group of claims, or a mine. In cases where a deposit has been known by more than one name, alternate names are given.

Name of owner or operator refers to the last known owner or operator.

Location is the latest available. In some cases there are discrepancies in the records which leave doubtful the precise location of certain deposits. An asterisk (*) preceding a number means that the mine to which it refers has not been plotted on the accompanying map because the location is not accurately known; a circle (°) means that the mine has not been plotted because of the crowded condition of the map. *Sec.* denotes section, *T.* Township, *R.* Range, and *B. & M.* Base and Meridian, of which there are three in California—Humboldt (*H.*), Mount Diablo (*M. D.*) and San Bernardino (*S. B.*). The California land net is shown on *Economic Mineral Map of California No. 6—Copper.* In areas that have not been surveyed into sections, particularly in parts of Inyo and San Bernardino Counties, locations have been approximated by projecting land lines.

Remarks and references. Geology is given briefly. Deposits in which copper is a byproduct are indicated, in many cases, by listing the chief metal or metals. References are chiefly to deposits in which copper is the main product or coproduct; full titles are given in the bibliography.

The list is necessarily incomplete, as it is virtually impossible to tabulate all the occurrences of copper in the State. Wherever errors or omissions are found, it is hoped that they will be called to the attention of the State Division of Mines in San Francisco.

ALAMEDA COUNTY

Number	Class by production	Name of deposit	Name of owner or operator	Location				Remarks and references
				Sec.	T.	R.	B. & M.	
1	B	Alma	Blowski Copper Co., 1328 Trestle Glen, Oakland, Calif. (1935)	34	1S	3W	MD	Predominantly a pyrite deposit used for production of sulphuric acid. Ore body 12-18 ft. wide in rhyolite, shows evidence of leaching and enrichment. Ore may average 1% copper. During period 1925-29 Alma and Leona Heights deposits produced over 322,000 lb. copper. Over 5,000 ft. of workings. (Aubury, L. E. 05, pp. 144-145; 08, pp. 169-170; Clark, C. W. 17; Davis, F. S. 04; Hodge, E. T. 35, v. 3, ap. E-5, p. 6; Huguenin, E. 21, pp. 32-33; Laizure, C. McK 29a, pp. 439-441; Lawson, A. C. 14, Concord areal geology sheet, p. 22; Mace, C. H. 11.)
2	B	Leona Heights	Blowski Copper Co., 1328 Trestle Glen, Oakland, Calif. (1935)	3	2S	3W	MD	Geologically similar to Alma; in same ore zone. Gossan mined for mineral paint. Ore bodies 24-40 ft. wide. Periods of activity parallel those of Alma. (Aubury, L. E. 05, pp. 145-146; 08, p. 170; Clark, C. W. 17; Davis, F. S. 04; Hodge, E. T. 35, v. 3, ap. E-5, p. 6; Huguenin, E. 21, pp. 32-33; Laizure, C. McK 29a, pp. 439-441; Lawson, A. C. 14, Concord areal geology sheet, p. 22; Mase, C. H. 11.)

ALPINE COUNTY

Number	Class by production	Name of deposit	Name of owner or operator	Location				Remarks and references
				Sec.	T.	R.	B. & M.	
								General references: Henry, J. L. 26; Mining and Scientific Press 84; Raymond, R. W. 70, pp. 79-82.
*1	C		H. D. Maitlen, Silver Lake, Calif. (1939)					Lead mine.
2	C	Advance (North Advance)	A. L. Stewart, Markleeville, Calif. (1938)	31, 32	10N	21E	MD	Silver mine; also gold, lead.
		Alpine: see Morning Star						
3	C	Alpine Fairview (Fairview)	Lapsid (1943)	1	11N	19E	MD	Mineralized structure 10-15 ft. wide, traceable 1,000 ft.; 165-ft. adit. Small shipments 1901, 1919; idle 1943. (Logan, C. A. 21, pp. 402-403; 23, pp. 361-362.)

		Curtz: see Morning Star						
4	D	Drumlummon claim	S. Castleman, Placerville, Calif. (1930)	2	10N	18E	MD	Gold-copper mine; pyrite, chalcopyrite. (Logan, C. A. 31a, p. 490.)
		Fairview: see Alpine Fairview						
		Georgia(na): see Morning Star						
5	C	Globe	A. F. Brune, Markleeville, Calif. (1943)	31	10N	21E	MD	Large silicified zones in andesite; occasional veinlike concentrations of copper ore. Cross-cut adit 1,000 ft.; drift 300 ft. Ore shipped in seventies; idle 1943. (Eakle, A. S. 19, p. 25; Logan, C. A. 21, p. 404; Raymond, R. W. 72, pp. 51-52; 73, pp. 94, 95; 73a, p. 14; 74, pp. 55, 57-58.)
*6	D?	Keneback		Approx.	10N	21E	MD	Copper mine. Near Morning Star. (Personal communication, George R. Heyl.)
7	B	Leviathan	Leviathan Sulphur Co., c/o E. C. Bierce, Markleeville, Calif. (1943)	14, 15 22, 23 26	10N	21E	MD	Native copper, native sulphur, cuprite, and carbonates, with gold and silver, in three gently dipping beds of andesite tuff. (Aubury, L. E. 05, p. 199; 08, p. 246; Irelan, W. Jr. 88, p. 38; Logan, C. A. 31a, p. 491; Neale, W. G. 27, p. 497; Rand, L. H. 31, p. 505; Raymond, R. W. 72, p. 51; 73, p. 95; 73a, pp. 15-16.)
		Lincoln: see Zaca						
8	C	Lost Cabin	C. Mailske, Jackson, Calif. (1939)					Gold mine; also silver, lead.
9	B	Morning Star (Alpine, Curtz, Georgiana, Orion)	Alpine Cons. Mining Co. *see* Howard A. Wilson, Markleeville, Calif. (1943)	29	10N	21E	MD	Copper-gold-silver mine. Lenses and veins in silicified zones in volcanics. Consists of two adits, higher one more than 900 ft. long, lower about 2,000 ft. long. Vertical shaft connects upper tunnel with surface. Enargite on dump. (Aubury, L. E. 05, p. 199; 08, p. 246; Eakle, A. S. 19, pp. 14-22; Irelan, W. Jr. 88, p. 38; Logan, C. A. 21, p. 403; 23, p. 362; 31a, p. 489; Rand, L. H. 31, pp. 483-484; Raymond, R. W. 72, p. 53; 73, p. 95; 73a, p. 15; Root, E. W. 68.)
		North Advance: see Advance						
		Orion: see Morning Star						
10	C	Stella	Alpine Cons. Mining Co. *see* Howard A. Wilson, Markleeville, Calif. (1943)	31	10N	21E	MD	Shaft 400 ft.; cement copper shipped in 1884. (Aubury, L. E. 05, p. 199; 08, p. 246.)
*11	C?	Uncle Billy Ro(d)gers						Discovered 1855, in Hope Valley. (Aubury, L. E. 05, p. 199; 08, p. 246; Irelan, W. Jr. 88, p. 37; Logan, C. A. 23, p. 361.)
12	C	Zaca (Lincoln)	Ballam & Drake, Markleeville, Calif. (1944)	31	10N	21E	MD	Tungsten mine. (Eakle, A. S. 19, p. 25; Gianella, V. P. 38; Irelan, W. Jr. 88, p. 38; Raymond, R. W. 74, pp. 54, 57-58; Tucker, W. B. 41, p. 565; Zimmerman, J. 42, p. 307.)

* Not shown on map because of lack of definite location.

AMADOR COUNTY

Number	Class by production	Name of deposit	Name of owner or operator	Location: Sec.	Location: T.	Location: R.	Location: B. & M.	Remarks and references
		Allen: see Hayward						
1	C	Amador Columbus	Amador Columbus Mines Co., San Francisco, Calif. (1940)	32	7N	13E	MD	Gold mine; also silver.
2	C	Amador Star (Rhetta, Hamburger, West American Consolidated Gold Mines)	H. Kaiser, Stockton, Calif. (1940)	23	8N	10E	MD	Gold mine; also silver, lead. (Logan, C. A. 35, pp. 61-62.)
3	C	Argonaut (Pioneer)	Argonaut Mining Co., Ltd., Jackson, Calif. (1942)	16, 17 20, 21 28, 29	6N	11E	MD	Gold mine; also silver. (Logan, C. A. 35, p. 62.)
4	C	Belden	Belden Amador Mines, Inc., Fort Wayne, Ind. (1942)	27?	7N	13E	MD	Gold (?) mine; also silver, lead.
5	C	Big Pine	R. Shaffner, Jamestown, Calif. (1942)	32	7N	13E	MD	Gold (?) mine; also silver, lead.
6	C	Bull Run		15	5N	10E	MD	Shipped during sixties; 400-ft. shaft. (Aubury, L. E. 05, p. 186; 08, p. 225; Logan, C. A. 27, p. 149.)
7	D	Chaparral		10	5N	10E	MD	Opened 1864; 120-ft. shaft. (Aubury, L. E. 05, p. 186; 08, p. 225.)
8	C	Coeur Leonis	J. Howald, Pine Grove, Calif. (1936)	26, 27	8N	10E	MD	Gold (?) mine; also silver, lead.
		Coney: see Zeile						
9	A	Copper Hill (Cosumnes, Hobo)	c/o Richard Detert, Mills Tower, San Francisco, Calif. Lessee, J. P. Donovan, Plymouth, Calif. (1943)	34, 35	8N	9E	MD	Drilled by U.S. Bureau of Mines, 1942-43. Two "veins" or silicified zones; "mineralized limestone" on dump. (Aubury, L. E. 05, pp. 186-187; 08, pp. 226-227; Logan, C. A. 27, p. 148; Raymond, R. W. 74, p. 87; Tucker, W. B. 16, pp. 12-13.)
		Cosumnes: see Copper Hill						
10	C	Defender	West Point Cons. Mines Co., New York, N.Y. (1940)	29, 32	7N	13E	MD	Gold (?) mine; also silver.
*11	C	Delta	Amador Metals Reduction Co., Martel, Calif. (1943)					Gold (?) mine; also silver, lead. On Rancho Arroyo Seco.
*12	C	Detroit	L. Ivancovich, Plymouth, Calif. (1913)					Gold (?) mine.

13	C	Elkhorn	J. Grillo, Volcano, Calif. (1942)	29, 32	7N	13E	MD	Gold (?) mine; also silver.
14	D	Forest Home		9	7N	9E	MD	Four shafts 80 ft. deep. (Aubury, L. E. 05, p. 187; 08, p. 227.)
15	C	Fort Ann	Kent and Nimmo, Volcano, Calif. (1942)	2	7N	12E	MD	Gold (?) mine; also silver, lead.
16	C	Fremont-Gover	Fremont Gover Co., Amador City, Calif. (1940)	24 25, 26	7N	10E	MD	Gold mine; also silver. (Logan, C. A. 35, pp. 82-84.)
17	C	Fuller	G.F. Fuller, Jackson, Calif. (1937)	27?	6N	11E	MD	Gold (?) mine.
18	C	Grand Prize	F. A. Kimball, Volcano, Calif. (1940)	29, 32	7N	13E	MD	Gold (?) mine.
		Grayhouse (Grey House): see Thayer						
		Hamburger: see Amador Star						
19	C	Hayward (Allen)	Allen Estate Co., Sutter Creek, Calif. (1943)	28	8N	10E	MD	Silicified, pyritized zone. (Tucker, W. B. 16, p. 12.)
		Hobo: see Copper Hill						
		Ione: see Ione Copper						
20	C	Ione City		3, 4	5N	10E	MD	Operated in sixties. (Aubury, L. E. 05, p. 186; 08, p. 225.)
		Ione Coal and Iron Company: see Ione Copper						
21	B	Ione Copper (Irish Hill)	Ione Coal and Iron Company, Ione, Calif. (1915)	11	6N	9E	MD	In greenstone just east of slate belt. Reported to have produced some stibnite as well as copper ores; also gold, silver, zinc. On Arroyo Seco Grant. (Aubury, L. E. 08, p. 227; Lang, H. 07, pp. 909, 964. 966; Logan, C. A. 27, p. 149; Tucker, W. B. 16, p. 13; Weed, W. H. 14, p. 477.)
		Irish Hill: see Ione Copper						
22	C	Italian	Black Hills Mining Co., Jackson, Calif. (1941)	24	7N	10E	MD	Gold mine; also silver. (Logan, C. A. 35, p. 85.)
23	D	Johnson Ranch		25 35, 36	6N	10E	MD	Shafts 90, 60 ft.; vein up to 12 ft. (Aubury, L. E. 08, p. 227; Tucker, W. B. 16, p. 13.)
24	C	Kennedy	Kennedy Mining & Milling Company, San Francisco, Calif. (1942)	17, 20 21, 22 27, 28	6N	11E	MD	Gold mine; also silver, lead. (Logan, C. A. 35, pp. 85-91.)
25	C	Keystone	Keystone Mines Syndicate, Amador City, Calif. (1942)	31, 36 6	7N 6N	10E 11E	MD MD	Gold mine; also silver; "pyrite deposit". (Logan, C. A. 35, pp. 91, 92-95, pl. 4.)
26	C	Mexican	F. L. Kimball, Pine Grove, Calif. (1940)	29	7N	13E	MD	Gold (?) mine.
27	D	Mineral City		10	7N	9E	MD	(Aubury, L. E. 05, p. 187; 08, p. 227.)

AMADOR COUNTY—Continued

Number	Class by production	Name of deposit	Name of owner or operator	Location Sec.	T.	R.	B. & M.	Remarks and references
28	D	Moon		3, 9, 10	5N	10E	MD	Shafts 140, 100 ft.; gossan. (Aubury, L. E. 05, 08 pp. 185-186; pp. 224-225; Tucker, W. B. 16, p. 13.)
29	D	Mutual Life Insurance		2	7N?	9E	MD	Five shafts. (Aubury, L. E. 05, p. 187; 08, p. 228.)
30	A	Newton	Dufrene Estate, lessee; J.H. Lester, sub-lessee; assigned to Winston Copper Co. July 1 1943; managed by Pacific Mining Co. for Winston Copper Company	28	6N	10E	MD	Drilled by U.S. Bureau of Mines, 1942-43. Chalcopyrite in greenstone; sericitized-pyritized footwall; a very little sphalerite at depth. (Aubury, L. E. 05, pp. 183-185; 08, pp. 222-224; Browne, J. R. 67, pp. 143, 149, 166-167; Irelan, W. Jr. 88, pp. 106-108; Logan, C. A. 27, p. 148; Raymond, R. W. 74, pp. 47, 87; Tucker, W. B. 16, p. 13.)
31	C	Nottus	F. M. Sutton, San Francisco, Calif. (1940)	29	7N	13E	MD	Gold (?) mine; also silver.
32	C	Original Amador	J. W. Bullock, Amador City, Calif. (1940)	36	7N	10E	MD	Gold mine; also silver. (Logan, C. A. 35, pp. 104-106.)
		Pioneer: see Argonaut						
33	C	Pioneer	Gwalia Gold Mining Co., Pine Grove, Calif. (1941)	20, 21, 22	7N	13E	MD	Gold mine; also silver, lead. (Logan, C. A. 35, p. 106.)
34	C	Plymouth Consolidated	Argonaut Mining Co., San Francisco, Calif. (1943)	11, 12, 14	7N	10E	MD	Gold mine; also silver. (Logan, C. A. 35, pp. 106-111, pl. 5.)
35	D	Questa	F. J. Questa (1943)	29?	6N	10E	MD	Shaft 60 ft.
		Rhetta: see Amador Star						
36	D	Russel		10	5N	10E	MD	Large dump; 200-ft. shaft. (Aubury, L. E. 05, p. 186; 08, p. 225.)
37	C	Thayer (Grayhouse, Grey House)	Lloyd Thayer, San Mateo, Calif. (1943)	23	5N	10E	MD	A north extension of Campo Seco, Calaveras County. Shaft 240 ft.; drilled by U.S. Bureau of Mines, 1943. (Aubury, L. E. 05, p. 186; 08, p. 225; Tucker, W. B. 16, p. 14.)
38	C	Three-in-One	Kent and Nimmo, Volcano, Calif. (1941)	3	7N	12E	MD	Gold (?) mine; also silver.
		West American Consolidated Gold Mines: see Amador Star						
		Zeila: see Zeile						
39	C	Zeile (Zeila, Coney)	Kennedy Mining & Milling Co., Jackson, Calif. (1940)	28	6N	11E	MD	Gold mine. (Logan, C. A. 35, pp. 115-116.)

* Not shown on map because of lack of definite location.

BUTTE COUNTY

Number	Class by production	Name of deposit	Name of owner or operator	Location				Remarks and references
				Sec.	T.	R.	B. & M.	
1	C	Banner	Amosky Banner Cons. Mines, San Francisco, Calif. (1942)	27, 28 33, 34	20N	4E	MD	Gold mine. (Logan, C. A. 31, pp. 369-370.)
2	A	Big Bend (Evening Star, Pinkston)	Hoefling Bros., 1820 D St., Sacramento, Calif. (1943)	8	21N	5E	MD	Zinc-copper mine; sphalerite in sericite schist in greenstone; chalcopyrite concentrate also produced. (Averill, C. V. 43b, pp. 312-313; Logan, C. A. 31, pp. 367, 372, 378.)
3	D	Bloomer Hill (Chambers)	J. F. Garrette, Woodland, Calif. (1929)	35	21N	4E	MD	Gold-copper mine; disseminated sulfides and siliceous replacements in amphibolite schist. (Logan, C. A. 31, pp. 370-371.)
4	C	Bonanza King	Thunen & Brereton, Oroville, Calif. (1941)	16	25N	5E	MD	Zinc-lead-copper-silver-gold mine; "Zn, 6%; Pb, 8%; Cu, 4%". (Logan, C. A. 31, pp. 367, 409.)
		Chambers: see Bloomer Hill						
		Evening Star: see Big Bend						(Logan, C. A. 31, pp. 367, 372-373.)
*5	C	Four L	G. J. Lindsay, Oroville, Calif. (1941)	Ap.	22N	6E	MD	Gold mine.
6	C	Gold Bank		5?	19N	6E	MD	Gold mine; cement copper produced. (Logan, C. A. 31, p. 367.)
7	C	IXL	H. G. Woolner, Yankee Hill, Calif. (1939)	20	22N	4E	MD	Gold mine; also silver. (Logan, C. A. 31, p. 376.)
8	C	Jacks Ranch	E. A. Haines, Oroville, Calif. (1935)	8	20N	5E	MD	Gold mine; also silver.
*9	C	Laughing Water	O. L. Tibbals, Oroville, Calif. (1935)					Gold mine; also silver.
		Pinkston: see Big Bend						(Logan, C. A. 31, p. 378.)
10	C	S & D	S. F. Thomas, Paradise, Calif. (1941)	3	22N	3E	MD	Gold mine; also silver.
11	C	Surcease	Hoefling Bros., Sacramento, Calif. (1943)	5, 6, 7	21N	5E	MD	Gold mine; also silver, lead. (Logan, C. A. 31, pp. 381-382.)

* Not shown on map because of lack of definite location.

CALAVERAS COUNTY

Number	Class by production	Name of deposit	Name of owner or operator	Location: Sec.	T.	R.	B. & M.	Remarks and references
*1	C		W. T. Benson, Milton, Calif. (1940)					Gold mine; also silver, lead.
*2	C		Eddy and Shiffer, Mokelumne Hill, Calif. (1941)					Gold mine; also silver, lead.
*3	C		J. H. Kelley, Copperopolis, Calif. (1941)					Copper mine (?).
*4	C		J. Williams, West Point, Calif. (1938)					Gold mine; also silver.
		Apex: see Ford						
°5	D	Bell Prince	W. H. Gallagher, Campo Seco, Calif. (1916)	4	4N	10E	MD	Three shafts 22, 61, and 100 ft. deep. (Tucker, W. B. 16a, p. 56.)
6	C	Black Wonder	Black Wonder Gold Mining Co., West Point, Calif. (1942)	22, 27	6N	14E	MD	Gold mine; also silver, lead. (Logan, C. A. 36a, p. 298.)
7	C	Bonanza		27, 34	5N	12E	MD	Some production before 1914.
		Borger: see Constellation						
8	C	Boston (Esperanza)	E. R. Solinsky, San Francisco, Calif. (1939)	5	5N	12E	MD	Gold mine; also silver. (Logan, C. A. 36a, p. 299.)
9	D	Bund		12	3N	12E	MD	Shafts 50, 75, and 108 ft. deep. (Tucker, W. B. 16a, p. 56.)
		Calaveras Copper: see Copperopolis mines						
10	C	Calaveras-Columbus	A.P. Dron, Berkeley, Calif. (1935)	20	5N	13E	MD	Gold mine.
11	C	Caldwell (Edna)	J. R. Hoskinson & Co., 810 N. Linden Dr., Beverly Hills, Calif. (1936)	11	4N	10E	MD	Gold mine. Massive gossan. Shaft 50 ft. on west vein, adit 150 ft. on east vein. (Logan, C. A. 36a, p. 303; Tucker, W. B. 16a, p. 57.)
12	D?	Caledonia		4?	3N	11E	MD	Copper prospect. (Heyl, G. R. 45, index map.)
		Campo Seco: see Penn						(Tucker, W. B. 16a, pp. 56-57.)
13	C	Carson Hill	Carson Hill Gold Mining Corp., San Francisco, Calif. (1944)	13, 14 17, 18 19, 20	2N 2N	13E 14E	MD MD	Gold mines; also silver, lead. (Logan, C. A. 36a, p. 300.)

14	D	Clothier and Cameron		2	2N	12E	MD	Shaft 35 ft. deep; 18-in. streak of ore. (Aubury, L. E. 08, p. 245.)
15	B	Collier	E. A. Vogt, 407 Montgomery St., San Francisco, Calif. (1943)	24	1N	11E	MD	Zinc (sphalerite)—copper (chalcopyrite) mine; also gold, silver, lead. Drilled by U.S. Bureau of Mines, 1944. (Aubury, L. E. 05, p. 197; 08, p. 244; Averill, C. V. 43b, p. 313; Logan, C. A. 36a, p. 301; Tucker, W. B. 16a, p. 57.)
16	B	Constellation (Borger, Constitution, San Francisco)	Borger Estate (1943)	3, 4	4N	10E	MD	Copper mine. Adjoins south end of Campo Seco ground; 1,500 ft. of workings, 400-ft. shaft; vein up to 5 ft. Diamond drilled by U.S. Bureau of Mines, 1943. (Aubury, L. E. 05, p. 196; 08, p. 242; Crawford, J. J. 94, p. 66; Irelan, W. Jr. 88, p. 156; Rand, L. H. 31, p. 534; Tucker, W. B. 16a, p. 57.)
		Constitution: see Constellation						
17	C	Copper Crescent	Copper Crescent Mining Co., Milton, Calif. (1916)	Approx. 26	1N	11E	MD	Copper mine; also gold, silver.
		Copper Hill: see Penn						(Irelan, W. Jr. 88, p. 156.)
18	A	Copperopolis mines: include Empire, Keystone-Union, and North Keystone mines		3 34	1N 2N	12E 12E	MD MD	Massive chalcopyrite in pyritized zone; also gold and silver. (Aubury, L. E. 05, pp. 189-194; 08, pp. 229-238; Browne, J. R. 67, p. 139; 68, pp. 211-212; Forstner, W. 08, p. 746; Hanks, H. G. 84, p. 148; Heyl, G. R. 45; Knopf, A. 06, pp. 418-422; Lang, H. 07, pp. 1007-1008; Logan, C. A. 23, p. 98; 24, p. 4; 24a, pp. 76-80; 25, p. 143; Neale, W. G. 27, pp. 444-446; Preston, E. B. 93, pp. 167-168; Rand, L. H. 31, pp. 511-514; Reid, J. A. 07; 08; Tolman, C. F. Jr. 35, p. 247; Tucker, W. B. 16a, pp. 62-63; Zimmerman, J. 37, p. 188.)
	C	Empire	F. Towers, Felix, Calif. (1939)	3	1N	12E	MD	
	A	Keystone-Union (Calaveras Copper)	Engels Copper Mining Co., San Francisco, Calif. (1929)	34	2N	12E	MD	Consolidation of Keystone and Union mines. Also produced from tailings, 1944-46.
	A	North Keystone	Calaveras Cons. Mining Co., Nevada City, Calif. (1943)	34	2N	12E	MD	Known as Keystone, 1942-46.
		Diamond J: see Telegraph						
		Eagle: see Quail Hill						(Aubury, L. E. 05, p. 197; 08, p. 244; Tucker, W. B. 16a, p. 57.)
19	C	Easyz Bird (Outlook, Pacific)	Le Roi Mines, Inc., Jackson, Calif. (1941)	6	5N	12E	MD	Gold mine. (Logan, C. A. 36a, p. 303.)
		Edna: see Caldwell						(Tucker, W. B. 16a, p. 57; Logan, C. A. 36a, p. 303.)
		Empire: see Copperopolis mines						
		Esperanza: see Boston						
20	C	Eureka	W. H. Thacker, Lodi, Calif. (1916)	33, 34	5N	11E	MD	Some production before 1912; shaft 150 ft. deep. (Tucker, W. B. 16a, p. 57.)
		Excelsior: see Star and Excelsior						

CALAVERAS COUNTY—Continued

Number	Class by production	Name of deposit	Name of owner or operator	Location Sec.	T.	R.	B. & M.	Remarks and references
21	C	Ford (Apex)	Mrs. A. Dower and T. Hawes, San Francisco, Calif. (1935)	16, 17	4N	12E	MD	Gold mine; also silver, lead. (Logan, C. A. 36a, p. 297.)
*22	C	Garland	H.H. Poch, Altaville, Calif. (1942)					Gold mine; also silver.
		Goat Ranch: see Nassau						(Logan, C. A. 36a, p. 306.)
23	C	Golden Storm	Porteus & Green Bros., West Point, Calif. (1941)	15	6N	13E	MD	Gold mine; also silver.
24	C	Gopher Hill (Gopher Ridge)	H. L. Donner. Lessees, F. T. Hanchett, San Jose, and F.W. H. Beauchamp, Copperopolis, Calif. (1943). Murphey owner.	10	1N	11E	MD	Copper mine. Shaft 80 ft. deep, with short drifts at 30 and 80 ft. (Logan, C. A. 36a, p. 262.)
		Gopher Ridge: see Gopher Hill						
25	C	Grey Eagle (Ingomar)	Ingomar Cons. Gold Mining Co., c/o A. Moss, R.F.D. 3, Box 609, San Jose, Calif. (1936)	34, 35	5N	10E	MD	Gold mine. Inclined shaft, 500 ft.; levels at 300, 380, and 500 ft.; gossan worked for gold. (Logan, C. A. 36a, p. 309; Tucker, W. B. 16a, p. 58.)
		Hecla: see Penn						
26	C	Heckendorn	W. H. Gardner, West Point, Calif. (1941)	18	6N	15E	MD	Gold mine; also silver. (Logan, C. A. 36a, p. 308.)
		Hinckley: see Penn						
27	C	Holmes	W. A. Holmes, Valley Springs, Calif. (1916)	2, 11	4N	10E	MD	Drift 365 ft. on east-trending vein (quartz). (Tucker, W. B. 16a, p. 57.)
		Ingomar: see Grey Eagle						(Tucker, W. B. 16a, p. 58; Logan, C. A. 36a, p. 309.)
28	D	Jackson McCarthy (Old Calaveras)		23	1N	12E	MD	Adjoins Copperopolis Empire claim on south; consists of two shallow shafts, with a stope between them. (Aubury, L. E. 05, p. 198.)
29	C	Josephine (Mountain Top)		8	1N	13E	MD	Shaft 40 ft. deep sunk in 1864; shipments in 1864. (Aubury, L. E. 05, p. 197.)
		Keystone: see Copperopolis mines						
		Keystone-Union: see Copperopolis mines						
		Lamphear: see Mother Lode Central						

		Lancha Plana (Satellite): see Penn						
		Libbie and Welch: see Lightner						
30	C	Lightner (Welch and Red Star; Libbie and Welch)	M. Elsasser Estate and Charlotte Elsasser (1943)	18	1N	13E	MD	Copper mine; some production as gossan gold mine; sulphide lenses 12-20 ft. wide; on same strike as Copperopolis; 50-ft. shaft. (Tucker, W. B. 16a, pp. 63-64.)
°30A	C	Little Quail Hill		24	1N	11E	MD	Copper mine. (Jenkins, O. P. 43, p. 560, pl. 8.)
		Little Satellite: see Penn						
31	C	Lucky Boy	J. P. Katsulakis, Oakland, Calif. (1939)	4	3N	12E	MD	Gold mine; also silver. (Logan, C. A. 36a, p. 311.)
		McCarthy: see Jackson McCarthy						
32	C	Mother Lode Central (Lamphear)	Mother Lode Central Mining Co., San Francisco, Calif. (1939)	18	5N	12E	MD	Gold mine; also silver, lead; 1½ miles south of Angels Camp. (Logan, C. A. 36a, p. 310.)
33	C	Mountain King	Jumbo Cons. Mining Co., Santa Monica, Calif. (1942)	19, 30 24	2N 2N	12E 11E	MD MD	Gold mine; also silver, lead. (Logan, C. A. 36a, p. 313.)
		Mountain Top: see Josephine						
34	A	Napoleon	E. H. Nutter, Rt. 2, Box 344, Redlands, Calif. Lessee (1943): Mountain Copper Co., Ltd., 216 Pine St., San Francisco, Calif.	23	1N	11E	MD	Copper-zinc mine; chalcopyrite and sphalerite in quartz porphyry and greenstone. Ore said to crosscut schistosity at angle of 40°; drilled 1942-43 by Mountain Copper Co., Ltd. Browne says this was second significant copper discovery in California. (Aubury, L. E. 05, pp. 196-197; 08, pp. 242-243; Averill, C. V. 43, p. 72; 43b, p. 314; Browne, J. R. 67, pp. 139, 147; Forstner, W. 08, p. 747; Knopf, A. 06, pp. 422-423; Logan, C. A. 26a, pp. 372, 373; 36a, p. 314; Neale, W. G. 27, p. 509; Tucker, W. B. 16a, p. 58; Weed, W. H. 06, p. 106; 16, p. 805; 20, p. 462.)
35	B	Nassau (Goat Ranch, Poole)	J. E. Knapp Co., San Francisco, Calif. (1943)	10	2N	12E	MD	Copper-zinc mine; chalcopyrite and sphalerite in green schist; footwall said to contain large low-grade deposit; shaft here reported 430 ft. deep; mine unwatered in 1941, by Harry Bush of Angels Camp, Calif. (Aubury, L. E. 05, p. 198; 08, p. 245; Forstner, W. 08, pp. 744, 747; Logan, C. A. 36a, p. 306; Neale, W. G. 27, p. 509; Tucker, W. B. 16a, pp. 58-59; Weed, W. H. 16, pp. 805-806; 18, p. 578.)
		North Keystone: see Copperopolis mines						
		Old Calaveras: see Jackson McCarthy						
36	C	Oro (y) Plata	Union Cons. Mining Co., San Francisco, Calif. (1942)	5, 6	3N	14E	MD	Gold mine; also silver, lead. (Logan, C. A. 36a, p. 315.)

CALAVERAS COUNTY—Continued

Number	Class by production	Name of deposit	Name of owner or operator	Location: Sec.	T.	R.	B. & M.	Remarks and references
		Outlook: see Easyz Bird						
		Pacific: see Easyz Bird						
37	A	Penn (Campo Seco, Copper Hill, Hecla, Hinckley, Penn Chemical Works, Satellite)	Penn Mining Co., Denver, Colorado (1944)	3, 4 33	4N 5N	10E 10E	MD MD	Zinc-copper mine; sphalerite-chalcopyrite in sericitized and silicified quartz porphyry and meta-felsite. Hecla is north portion, Hinckley east portion, of Penn mine. (Aubury, L. E. 05, pp. 194-196; 08, pp. 238-242; Browne, J. R. 67, p. 146; 68, p. 212; Crawford, J. J. 96, p. 57; Forstner, W. 08, p. 746; Hanks, H. G. 84, p. 148; Irelan, W. Jr. 88, pp. 152-156; Julihn, C. E. 38, pp. 112-116; Knopf, A. 06, pp. 415-418; Logan, C. A. 26a, pp. 372-374; 36a, p. 298; Tolman, C. F. Jr. 35, pp. 247-250; Tucker, W. B. 16a, pp. 59-62, Wiebelt, F. J. 48.)
		Penn Chemical Works: see Penn						
38	C	Plymouth Rock	H. E. Barker, Jenny Lind, Calif. (1935)	23	3N	10E	MD	Gold mine; also silver, lead. (Logan, C. A. 36a, p. 316.)
		Pool (e): see Nassau						(Aubury, L. E. 05, p. 198; 08, p. 245.)
39	A	Quail Hill (Eagle)	G. Ivan Smith, 4333 E. Florence Ave., Bell, Calif. (1943)	3, 10	1N	11E	MD	Zinc-copper-silver-gold mine; also lead. Browne says this was the first copper discovery of consequence in California; as it was mined for gold at first, Napoleon mine may be considered first. Sphalerite and chalcopyrite in alteration zone. (Aubury, L. E. 05, p. 197; 08, p. 244; Averill, C. V. 43b, p. 314; Browne, J. R. 67, p 139; Heyl, G. R. 45a, Silliman, B. 68, pp. 93-95; Tucker, W. B. 16a, pp. 57, 62.)
40	C	Ranch (Sherman Ranch)	J. T. McCarty, Copperopolis, Calif. (1942)	33	3N	11E	MD	Gold mine; also silver. (Logan, C. A. 25, p. 159; Julihn, C. E. 38, pp. 134-135.)
41	C	Royal	Western Empire Mines Co., Ltd., Milton, Calif. (1944)	24 19, 20, 29, 30	2N 2N	11E 12E	MD MD	Gold mine. (Logan, C. A. 36a, p. 318.)
		San Francisco: see Constellation						(Crawford, J. J. 94, p. 66; Irelan, W. Jr. 88, p. 156.)
		Sat(t)ellite: see Penn						(Logan, C. A. 36a, p. 298.)
42	C	Sheep Ranch	St. Joseph Lead Co., New York, N. Y. (1942)	7, 8, 17, 18	4N	14E	MD	Gold mine; also silver. (Logan, C. A. 36a, p. 318.)

		Sherman Ranch: see Ranch						
°43	D	Shumate	E. A. Vogt, 407 Montgomery St., San Francisco, Calif. (1943)	25	1N	11E	MD	Shaft unwatered in 1943.
°44	D	Star and Excelsior	W. A. Nuner, San Andreas, Calif. (1936)	24	1N	11E	MD	Copper-gold mine; patented claim. (Aubury, L. E. 05, p. 197; 08, p. 244; Logan, C. A. 36a, p. 319; Tucker, W. B. 16a, p. 62.)
45	C	Telegraph (Diamond J)	L. Shumate, Copperopolis, Calif. (1916)	26	1N	11E	MD	Production 1865, 1914. (Tucker, W. B. 16a, p. 57.)
		Union: see Copperopolis mines						(Tucker, W. B. 16a, pp. 62-63.)
		Welch and (Red) Star: see Lightner						(Tucker, W. B. 16a, pp. 63-64.)
46	C	Woodhouse	W. W. Gibson, Alameda, Calif. (1939)	8, 17	6N	13E	MD	Gold mine; also silver. (Logan, C. A. 36a, p. 323.)
*47	C	Yellow Aster	Furst & Noel, West Point, Calif. (1938)					Gold mine (?).

* Not shown on map because of lack of definite location.
° Not shown on map because of crowded condition.

COLUSA COUNTY

Number	Class by production	Name of deposit	Name of owner or operator	Location: Sec.	T.	R.	B. & M.	Remarks and references
1	D	Blackbird		19, 20	16N	6W	MD	In serpentine. (Aubury, L. E. 05, p. 132; 08, p. 159.)
2	D	Gem		21?	16N	6W	MD	(Aubury, L. E. 05, p. 132; 08, p. 159.)
3	D	Gray Eagle		20	16N	6W	MD	In serpentine; shaft 20 ft., adit 200 ft. (Aubury, L. E. 05, pp. 132-133; 08, p. 159; Pabst, A. 38, p. 28.)
4	C	Lion		17	17N	6W	MD	Vein said to be 4 ft. wide; 2 shafts, 1 adit. Discovered 1861, small smelter built to handle ore; some picked ore shipped to Selby smelter in early days. (Aubury, L. E. 05, p. 134; 08, p. 160; Bradley, W. W. 16, p. 178; Goodyear, W. A. 90, p. 158; Pabst, A. 38, p. 28.)
5	D	Mark Hanna Oil Company		35	17N	7W	MD	(Aubury, L. E. 05, p. 134; 08, p. 160.)
6	C	Pacific		21?	16N	6W	MD	Shafts 50, 45, 25 ft.; one in serpentine. Small shipments. (Aubury, L. E. 05, p. 133; 08, p. 159.)
7	D	Ruby King		29, 32	17N	6W	MD	(Aubury, L. E. 05, pp. 133-134; 08, p. 160.)

CONTRA COSTA COUNTY

Number	Class by production	Name of deposit	Name of owner or operator	Location: Sec.	T.	R.	B. & M.	Remarks and references
1	D	Eagle Peak		26	1N	1W	MD	(Aubury, L. E. 08, p. 171; Laizure, C. McK. 27, p. 15.)
2	C	Mount Zion		27	1N	1W	MD	Copper mine. Small output in 1901, 1918. (Laizure, C. McK. 27, p. 15, Aubury, L. E. 08, p. 171.)

DEL NORTE COUNTY

Number	Class by production	Name of deposit	Name of owner or operator	Location: Sec.	T.	R.	B. & M.	Remarks and references
1	D	Alameda		11	18N	3E	H	Chalcopyrite and gold; short adits; in diorite. (Aubury, L. E. 05, p. 115; 08, p. 139.)
2	B	Alta (Alta California)	C. M. Bacon, 57 Hillcrest Ave., Melrose, Mass.	35	18N	1E	H	Copper mine; red oxides of copper in serpentine; low grade at depth. Production mostly in '60s. (Aubury, L. E. 05, p. 114; 08, pp. 136-138; Browne, J. R. 67, pp. 153-154; 68, p. 214; Crawford, J. J. 96, p. 57; Laizure, C. McK 25a, p. 287; Lowell, F. L. 16, p. 382; Maxson, J. H. 33, pp. 144-145, 148; McGregor, A. 90, p. 167; Stevens, H. J. 11, p. 1511.)
3	D	Anderson		11	18N	3E	H	Copper mine; chalcopyrite and pyrite, on contact between Patrick greenstone and Galice shale; four short adits. (Maxson, J. H. 33, p. 147.)
		Atlantic-Pacific: see Superior						
4	D	Aurora		36	16N	2E	H	Oxide minerals in 6-ft. vein. (Aubury, L. E. 05, p. 114; Crawford, J. J. 96, p. 58.)
5	D	Bears Nest		36	19N	2E	H	Long adit on a 9-ft. vein of pyrrhotite with some copper, gold, silver. (Aubury, L. E. 05, p. 115; 08, p. 138.)
6	D	Britten		9	18N	3E	H	Copper mine. Three adits, one 340 ft.; drifts, 120 ft.; 60-ft. winze on 9-ft. vein, in schist and diorite. (Lowell, F. L. 16, p. 385; Maxson, J. H. 33, p. 147.)
7	D	Call		11	18N	3E	H	Adits and shafts on irregular bodies in serpentine. (Aubury, L. E. 05, p. 115; 08, p. 139.)
8	D	Chicago Camp (Del Norte Camp)	K. J. Khoeery (1933)	29	18N	5E	H	Copper mine; chalcopyrite and pyrite. Extensively developed 1917-18, but not an impressive showing. Large ore body said to have been found by diamond drilling at 300-ft. depth. Country rock serpentine. Low-grade ore on dumps. (Maxson, J. H. 33, p. 147.)
8A	C	Cleopatra (Dedrick)		3, 4	18N	2E	H	Copper mine. (Lowell, F. L. 16, p. 384; Maxson, J. H. 33, p. 148.)
°9	D	Copper Hill group		35	18N	1E	H	High-grade sulphides, oxides, and carbonates. (Aubury, L. E. 05, p. 114, map on p. 113.)
		Dedrick: see Cleopatra						
10	D	Del Norte	Carlton Bosch, Smith River, Calif. (1944)	19	17N	2E	H	(Aubury, L. E. 05, p. 116; 08, p. 139.)
		Del Norte Camp: see Chicago Camp						

DEL NORTE COUNTY—Continued

Number	Class by production	Name of deposit	Name of owner or operator	Location: Sec.	T.	R.	B. & M.	Remarks and references
11	D	Doctor Rock	Martha Thompson, Orick, Calif. (1931)	12	13N	3E	H	Copper mine; also gold. Shaft 10 ft. and adit 30 ft. on quartz vein carrying chalcopyrite and gold. At serpentine-shale contact. Sixteen miles of trail to mine. (Aubury, L. E. 05, p. 116; 08, p. 139; Laizure, C. McK 25a, p. 287; Lowell, F. L. 16, p. 386; Rand, L. H. 31, p. 541.)
12	D	Edwards	Mrs. W. Russell, Crescent City, Calif. (1944)	31	17N	2E	H	Some rich chalcocite; adit 40 ft. (Lowell, F. L. 16, p. 386.)
13	D	Eva		16	18N	3E	H	Sulphides with quartz. (Aubury, L. E. 05, p. 115; 08, p. 139.)
°14	D	Express		26, 35	18N	1E	H	(Aubury, L. E. 05, p. 114, map on p. 113.)
15	D	Five Diamonds		11	18N	2E	H	(Aubury, L. E. 05, p. 115; 08, p. 138.)
16	D	Flag		23	18N	3E	H	
17	C	French Hill		31	16N	2E	H	Copper mine; open cut. Sulphides genetically associated with Patrick greenstone. (Maxson, J. H. 33, p. 147.)
18	D	Higgins Mountain		25	17N	3E	H	Copper mine; open cuts on oxidized copper minerals in serpentine. (Aubury, L. E. 05, p. 116; 08, p. 140; Maxson, J. H. 33, p. 147.)
19	D	Hunters Luck		1	18N	3E	H	Copper mine; adits 160, 120 ft., on 8-ft. vein at serpentine—porphyry contact. (Laizure, C. McK 25a, p. 288; Lowell, F. L. 16, pp. 384-385.)
*20	C	Idora		Approx.	18N	1E	H	(Lowell, F. L. 16, p. 384.)
21	C	Keystone		32	19N	2E	H	"Copper glance, red and black oxides, carbonates, and native copper in serpentine". Cuts, short adits; 5 tons high-grade shipped to smelter. (Aubury, L. E. 05, p. 115; 08, p. 138.)
		Klondike: see Schofield						
*22	D	Lucky Boy and Rosebud			18N	3E	H	Low-grade copper in quartz; two adits, 80 ft. (Lowell, F. L. 16, p. 385.)
		Mammoth: see Superior						(Aubury, L. E. 05, p. 114; 08, p. 136.)
23	D	McKee		9	18N	2E	H	(Aubury L. E. 05, p. 115; 08, p. 138.)
24	D	Monkey Creek	Arcalore Mining Co., Long Beach, Calif. (1943)	5	17N	4E	H	Short adits on vein in diorite. (Aubury, L. E. 05, p. 116; 08, p. 140.)
°25	D	Occidental		2	17N	1E	H	(Aubury, L. E. 05, p. 114; 08, p. 136; Laizure, C. McK 25a, p. 288.)

26	D	Old Crow		2	18N	3E	H	Two adits fail to reach 2-ft. vein. (Lowell, F. L. 16, p. 385.)
		Oriental: see Zaar						
27	D	Prudential		2	18N	2E	H	Chief values in gold; two north-trending bodies carry small percentage of copper and zinc; adit and shaft. (Aubury, L. E. 05, p. 116; 08, p. 139.)
28	B	Salt Lake-California (Union)	Salt Lake-California Copper Co., Smith River, Calif. (1929)	35	18N	1E	H	Copper mine. (Laizure, C. McK 25a, pp. 288-289; Lowell, F. L. 16, pp. 382-383; Maxson, J. H. 33, pp. 144, 148.)
29	D	Sanger Peak		5?	17N	5E	H	Copper mine. Diamond drilling and exploration carried out previous to 1924. (Laizure, C. McK 25a, p. 288.)
30	D	Schofield (Klondike)		14	18N	3E	H	Copper mine. Three adits; one 300-ft. adit cuts a 4-5 ft. quartz-chalcopyrite vein 150 ft. below outcrop. Vein in Patrick greenstone. (Laizure, C. McK 25a, pp. 288-289; Lowell, F. L. 16, p. 385; Maxson, J. H. 33, p. 147.)
°31	C	Superior (Atlantic-Pacific, Mammoth)		26	18N	1E	H	Copper mine. (Aubury, L. E. 05, p. 114; 08, p. 138; Laizure, C. McK 25a, p. 289; Lowell, F. L. 16, p. 383.)
32	D	Tuesday Morning		15	18N	3E	H	Pyrite, chalcopyrite, and gold. (Aubury, L. E. 05, p. 116; 08, p. 139.)
		Union: see Salt Lake-California						(Aubury, L. E. 05, p. 114; 08, p. 137.)
°33	D	Zaar (Zoar, Oriental)		35	18N	1E	H	(Laizure, C. McK 25a, p. 288; Maxson, J. H. 33, pp. 148-149.)
		Zoar: see Zaar						

* Not shown on map because of lack of definite location.
° Not shown on map because of crowded condition.

EL DORADO COUNTY

Number	Class by production	Name of deposit	Name of owner or operator	Location				Remarks and references
				Sec.	T.	R.	B. & M.	
*1	C		Gardner & Phillips, Placerville, Calif. (1942)					Gold mine; also silver.
2	D	Agara		19	8N	9E	MD	Copper mine; 25-ft. shaft. (Aubury, L. E. 05, p. 180; 08, p. 216; Logan, C. A. 26b, p. 408; 38, p. 213.)
3	C	Alabaster Cave		10, 15	11N	8E	MD	Copper mine; one 300-ft. shaft, two 50-ft. shafts; 130 ft. of adits; native copper. (Aubury, L. E. 05, p. 176; 08, p. 211; Logan, C. A. 26b, p. 408; 38, p. 213; Pabst, A. 38, p. 28; Tucker, W. B. 19c, p. 276.)
4	C	Alhambra	Alhambra-Shumway Mines, Inc., Fresno, Calif. (1943)	6, 7	11N	11E	MD	Gold mine; also silver. (Logan, C. A. 38, p. 216.)
5	C	Amazon	Hillgren & Cole, Kelsey, Calif. (1934)	11	11N	10E	MD	Gold mine.
6	D	Arizona		24	12N	10E	MD	Copper mine. (Aubury, L. E. 05, p. 178; 08, p. 214; Logan, C. A. 38, p. 213.)
7	D?	Baker		28	10N	11E	MD	(Forstner, W. 08, p. 745.)
		Baldwin: see Briarcliffe						
8	D	Barklege & Miller		13	12N	10E	MD	Adit, 118 ft. (Aubury, L. E. 05, p. 178; 08, p. 214.)
9	C	Beebe	Pacific Mining Co., San Francisco, Calif. (1942)	15, 16 2, 11	12N	10E	MD	Gold mine; also silver, lead. (Logan, C. A. 38, p. 217.)
10	C	Big Buzzard (Darrington Ranch, Hercules, Buzzard)	P. F. Taylor, Folsom, Calif. (1944)	29	11N	8E	MD	Zinc-copper mine. (Averill, C. V. 43, p. 72; Logan, C. A. 38, p. 213.)
11	B	Big Canyon (Oro Fino)	Bradley Mining Co. (1943); Mountain Copper Co., Ltd., San Francisco, Calif. (1940)	29	9N	10E	MD	Gold mine; copper by-product. (Logan, C. A. 38, p. 220.)
12	C	Black Oak	R. J. Wilson, Midpines, Calif. (1942)	34	12N	10E	MD	Gold mine. (Logan, C. A. 38, p. 223.)
°13	C?	Blue Cat (Madelina, Madeline, Magdalena)	W. G. Busick, Box 47, El Dorado, Calif. (1943)	18	9N	11E	MD	Copper mine; south extension of Noonday (Storms, W. H. 00, p. 91.)
		Bob: see Iron Crown						

14	C	Boston	G. M. Allen (1938)	18	11N	9E	MD	Copper mine; 400-ft. shaft. Production in sixties. (Aubury, L. E. 05, p. 261; 08, p. 216; Logan, C. A. 26b, p. 408; 38, p. 213.)
15	C	Breala		2	8N	9E	MD	Copper mine; 70 ft. of old shaft reopened in 1917. (Logan, C. A. 26b, pp. 407-408; 38, p. 213.)
16	C	Briarcliffe (Baldwin, Nashville)	Briarcliffe Mines, Ltd., London, Ont., Canada (1941)	1, 12	8N	10E	MD	Gold mine. (Logan, C. A. 38, p. 226.)
17	C	Bryant Ranch		2	8N	9E	MD	65-ft. shaft; worked during sixties. (Aubury, L. E. 05, p. 180.)
18	C	Bunker Hill		14	12N	9E	MD	Copper mine; 60-ft. shaft; shipments made during sixties. (Aubury, L. E. 05, p. 181; 08, p. 219; Logan, C. A. 26b, p. 408; 38, p. 213.)
		Buzzard: see Big Buzzard						
*19	C	California-Aztec	California Aztec Mining Co., Placerville, Calif. (1942)					Gold mine; also silver.
20	C	Cambrian	Incindia G. Hassey, c/o Dodge & Saltzman, 9 E. 40th St., New York, N. Y. (1943)	23	11N	9E	MD	Copper mine; wide veins with small percentage of copper. Opened in fifties; active about 1900. Several thousand feet of adits. (Aubury, L. E. 05, p. 177; 08, pp. 213-214, 218; Eakle, A. S. 14, p. 17; Logan, C. A. 38, p. 213; Pabst, A. 38, p. 28; Tucker, W. B. 19c, p. 276.)
21	C	Camel Back (Voss)	J. D. Voss, Elk Grove, Calif. (1926)	11	11N	8E	MD	Copper mine; quartz vein containing copper sulphides and oxides strikes N. 32° E., dips 80° W., ranges up to 28 ft. in width; 3,500 ft. of croppings. Several adits. (Logan, C. A. 21, p. 430; 26b, p. 407; 38, p. 213.)
22	C	Cosumnes	Harry Williams and George Thomas, Jackson, Calif. (1943); Cosumnes Mines, Inc., Grizzly Flats, Calif. (1942)	24, 25	9N	12E	MD	Gold mine; also lead, silver; copper by-product; ore contains molybdenite. (Aubury, L. E. 05, p. 178; 08, p. 214; Crawford, J. J. 96, p. 58; Logan, C. A. 26b, p. 408; 38, p. 213; Pabst, A. 38, p. 28; Tucker, W. B. 19c, p. 277.)
23	C	Cothrin		29	9N	9E	MD	Copper mine; old shaft, 100 ft.; produced previous to 1926. (Logan, C. A. 26b, p. 407; 38, p. 213.)
24	C	Costa Ranch		12	11N	8E	MD	Copper mine; shaft, 60 ft. (Aubury, L. E. 08, p. 218; Logan, C. A. 26b, p. 408; 38, p. 213.)
25	D	Copper Chief		12	12N	10E	MD	Copper mine. (Aubury, L. E. 05, p. 180; 08, p. 216; Logan, C. A. 26b, p. 408; 38, p. 213.)
26	C	Contraband (Ford)		24	12N	10E	MD	Copper mine; also asbestos; 65-ft. shaft; adits; small production 1860-1910. (Aubury, L. E. 05, p. 178; 02, p. 17; 08, p. 214; Logan, C. A. 26b, p. 408; 38, p. 213.)
		Darrington Ranch: see Big Buzzard						
		Diamond Springs: see Larkin						(Lang, H. 07, p. 963; Logan, C. A. 38, p. 213.)
27	D	Doctor Wren	Clarence Padilla, El Dorado, Calif. (1943)	7	9N	11E	MD	Copper mine. (Aubury, L. E. 05, p. 180; 08, p. 216; Logan, C. A. 26b, p. 408; 38, p. 213.)

EL DORADO COUNTY—Continued

Number	Class by production	Name of deposit	Name of owner or operator	Location				Remarks and references
				Sec.	T.	R.	B. & M.	
		Dodson: see Rip and Tear						
28	C	E. E. Copper	Kileen, Oakland, Calif.	18	9N	11E	MD	Copper mine; vein about 2 ft. wide; 85-ft. shaft, 300 ft. of drifts, 400 ft. of adits. (Aubury, L. E. 08, p. 218; Logan, C. A. 26b, p. 408; 38, p. 213; Tucker, W. B. 19c, p. 277.)
29	C?	El Dorado		34?	12N	10E	MD	Copper mine; shallow shaft and short adit. Drilled by U.S. Bureau of Mines, 1945. (Bedford, R. H. 46.)
		Ford: see Contraband						
30	C	Fox	H. H. Smith, Placerville, Calif. (1924)	4	10N	10E	MD	Gold mine; also silver, lead.
31	C	Funny Bug (Pendelco)	H. H. Smith, Rt. 2, Box 192, Placerville, Calif. (1943); lessee, Volo Mining Co., Placerville	5	10N	10E	MD	Gold mine; some copper, also silver; chalcopyrite in fractures in augite diorite. (Logan, C. A. 38, p. 242.)
		Gold Reserve: see Pyramid						
32	C	Grit	H. Baughman, Sacramento, Calif. (1926)	30	13N	10E	MD	Gold mine. (Logan, C. A. 38, p. 262.)
33	D	Hale		25	9N	12E	MD	Copper mine; south extension of Cosumnes (gold). (Aubury, L. E. 08, p. 217; Logan, C. A. 26b, p. 408; 38, p. 213.)
		Hercules: see Big Buzzard						
34	D	Homestead		26	13N	10E	MD	Gold mine. (Logan, C. A. 38, p. 263.)
35	C	Humbug (Morey)	E. W. Morey, Grizzly Flats, Calif. (1937)	16	9N	13E	MD	Gold mine; also silver, lead. (Logan, C. A. 38, p. 241.)
36	C	Irland		15	10N	10E	MD	Copper mine; shaft, 75 ft.; small production 1866, 1906. (Aubury, L. E. 08, p. 218; Logan, C. A. 26b, p. 408; 38, p. 213.)
37	D	Iron Crown (Bob)		13	12N	10E	MD	Copper mine, developed principally for gold; wide gossan; shaft 75 ft. (Aubury, L. E. 05, p. 181; 08, p. 219; Logan, C.A. 26b, p. 408; 38, p. 213; Tucker, W. B. 19c, p. 276.)
38	D	Kelly	M. Kelly, Kelsey, Calif. (1939)	13	11N	10E	MD	Gold mine; network of veins; 2,000 ft. of adits. (Aubury, L. E. 05, p. 176; 08, p. 212; Logan, C. A. 38, p. 263.)
39	C	Kelsey	Kelsey Mining Co., San Francisco, Calif. (1939)	24, 25	11N	10E	MD	Gold mine; also silver. (Logan, C. A. 38, p. 235.)

40	C	Larkin (Diamond Springs)	Charles Ball, Placerville, Calif. (1943)	29	10N	11E	MD	Gold-copper mine; shaft, 160 ft.; vein, 3 ft.; production 1918; near railroad. (Aubury, L. E. 08, p. 217; Logan, C. A. 26b, p. 40; 38, p. 213; Tucker, W. B. 19c, p. 277.)
41	C	Lilyama (Little Emma, Volo)	G. H. Mitchel, Los Angeles, Calif. (1944); lessee, Volo Mining Co., Placerville, Calif. (1943)	3	11N	9E	MD	Copper mine; also gold, silver. Has approximately 1,000 ft. of workings. Lilyama and Pioneer are the only contact-metamorphic copper deposits known to occur in the Foothill belt. There is a mixup in the literature about which is Lilyama mine and which is Pioneer; most writers place Lilyama southwest of Pioneer; U.S.G.S. places it northeast of Pioneer. (Aubury, L. E. 05, pp. 176-177; 08, pp. 212-213; Averill, C. V. 43, p. 140; Logan, C. A. 26b, p. 408; 38, p. 213; Tucker, W. B. 19c, p. 277.)
		Little Emma: see Lilyama						(Aubury, L. E. 08, p. 212; Logan, C. A. 26b, p. 408; 38, p. 213.)
		Madeline: see Blue Cat						
		Magdalena: see Blue Cat						
42	D	Middle End	Cosumnes Mines, Inc., Grizzly Flats, Calif. (1939)	3, 4	9N	13E	MD	Gold mine; also silver, lead. (Logan, C. A. 38, p. 265.)
43	C	Montezuma	Montezuma Apex Mining Co., Placerville, Calif. (1939)	2 35	8N 9N	10E 10E	MD MD	Gold mine; also silver. (Logan, C. A. 38, p. 238.)
		Morey: see Humbug						
44	C	Mount Pleasant	c/o J. D. Elliot, Placerville, Calif. (1943)	16	9N	13E	MD	Gold mine; also lead, zinc; copper by-product. (Logan, C. A. 23, p. 210; 38, p. 241.)
		Nashville: see Briarcliffe						
45	B	Noonday	Frank Fausel, Placerville, Calif. (1943)	18	9N	11E	MD	Copper mine; chalcopyrite and pyrite in schist; mine is ½ mile east of Mother Lode; worked about 1900-05; shaft 230 ft., and adit. (Aubury, L. E. 05, p. 182; 02, p. 17; 08, p. 220; Logan, C. A. 38, p. 213; Tucker, W. B. 19c, p. 278.)
		Oro Fino: see Big Canyon						
		Pendelco: see Funny Bug						
46	C	Pioneer	Lessee, Volo Mining Co., Placerville, Calif.	9	11N	9E	MD	An extension of Lilyama (which see); approximately 200 ft. of workings. (Aubury, L. E. 05, p. 177; 02, p. 17; 08, pp. 213, 218; Logan, C. A. 26b, p. 408; Tucker, W. B. 19c, p. 278.)
47	C	Pyramid (Gold Reserve)	G. R. Grimshaw & Assoc., Auburn, Calif. (1938)	12, 13	10N	9E	MD	Gold mine; also silver. (Logan, C. A. 38, p. 244.)
48	D	Revoir		12	9N	12E	MD	Copper mine; south extension of Costa mine. (Aubury, L. E. 08, p. 217; Logan, C. A. 26b, p. 408; 38, p. 213.)
49	C	Rip and Tear (Dodson)	R. L. Dodson, Latrobe, Calif. (1943)	3	8N	9E	MD	Copper mine; heavy sulphide ore; 90-ft. shaft; 2 carloads ore shipped in 1918. (Aubury, L. E. 05, p. 181; 08, p. 219; Averill, C. V. 43a, p. 140; Logan, C. A. 26b, p. 408.)

EL DORADO COUNTY—Continued

Number	Class by production	Name of deposit	Name of owner or operator	Location Sec.	T.	R.	B. & M.	Remarks and references
50	D	Robert		13	9N	11E	MD	Copper mine; 80-ft. shaft, 150-ft. adit. (Aubury, L. E. 05, p. 180; 08, p. 216; Logan, C. A. 26b, p. 408; 38, p. 213; Tucker, W. B. 19c, p. 278.)
51	C	Rosecrans (Rozecrans, Rosecranz)	Lode Development Co., Garden Valley, Calif. (1939)	21	12N	10E	MD	Gold mine; also silver. (Logan, C. A. 38, p. 248.)
52	D?	Seven Bells (Sporting Boy)		10	10N	10E	MD	Copper mine, 4 mi. west of Placerville. (Logan, C. A. 26b, p. 408.)
53	C	Sliger	Middle Fork Gold Mining Co., Auburn, Calif. (1942)	25, 36	13N	9E	MD	Gold mine; also silver, lead; located a short distance west of the Mother Lode. (Logan, C. A. 38, p. 250.)
		Sporting Boy: see Seven Bells						
		Springfield: see Union						
54	C?	Union (Springfield)	El Dorado Mining Co., Spokane, Wash. (1938)	1, 12 13, 14	9N	10E	MD	Gold mine; also silver; located west of Mother Lode. (Logan, C. A. 38, p. 251.)
		Volo: see Lilyama						
		Voss: see Camel Back						
55	D	Woods		4	8N	9E	MD	(Aubury, L. E. 05, p. 181; 08, p. 219.)

* Not shown on map because of lack of definite location.
° Not shown on map because of crowded condition.

FRESNO COUNTY

Number	Class by production	Name of deposit	Name of owner or operator	Location Sec.	T.	R.	B. & M.	Remarks and references
1	D	Ackers (Exposition and Summit)	Henry Ackers, Sanger, Calif. (1916)	10	12S	24E	MD	400 feet of workings. (Bradley, W. W. 16a, p. 437; Crawford, J. J. 96, p. 58.)
2	D	Anderson and Gist		14, 15 23, 24	12S	24E	MD	(Aubury, L. E. 05, p. 233; 08, p. 288.)
3	D	Badders		9, 10	13S	31E	MD	(Aubury, L. E. 05, p. 233; 08, p. 288.)

4	D	Black Mountain		36	11S	23E	MD	Vein in limestone; 400 ft. of workings. (Aubury, L. E. 05, p. 232; 08, p. 287.)
5	D	Blackjack	V. F. Moore, King River, Calif. (1918?)	14	12S	24E	MD	150 ft. of workings. (Bradley, W. W. 16a, p. 437.)
6	D	Buck's Peak		12	12S	23E	MD	(Aubury, L. E. 05, p. 232; 08, pp. 287-288.)
7	A	Copper King (Hart)	John Davis, Sanger, Calif. (1943)	3	12S	23E	MD	Lens in schist surrounded by granite; two inclined shafts, 700 and 800 ft. deep; pyrite and chalcopyrite, and a little sphalerite and gold. (Aubury, L. E. 05, pp. 226-230; 08 pp. 282-286; Bradley, W. W. 16a, p. 437; Crawford J. J. 94 p. 66; 96, p. 59; Laizure, C. McK 29, p. 308; Lang, H. 07, pp. 913, 963, 966, 1008, 1010; Neale, W. G. 27, p. 460; Rand, L. H. 31, p. 535.)
		Exposition and Summit: see Ackers						
8	A	Fresno (Heiskell)	John Parks, Los Angeles, Calif. (1943)	10	12S	21E	MD	Several lenses containing pyrrhotite and chalcopyrite, in sericite schist; 530-ft. shaft; idle since 1910. (Aubury, L. E. 05, p. 226; 08, pp. 279-281; Bradley, W. W. 16a, p. 437; Forstner, W. 08, p. 747; Laizure, C. McK 29, p. 226; Lang, H. 07, pp. 911, 913, 963, 1008; Preston, E. B. 93a, p. 222.)
9	D	Grubstake		15	12S	23E	MD	(Aubury, L. E. 05, p. 230; 08, p. 288.)
10	D	Happy Camp		6	12S	24E	MD	150 ft. of workings. (Aubury, L. E. 05, p. 232; 08, p. 288.)
		Hart: see Copper King						
		Heiskell: see Fresno						
11	D	Hinkle		25, 26 27	12S	24E	MD	(Aubury, L. E. 05, p. 233; 08, p. 288.)
12	D	Kenawyer (Kings River Canyon?)		11	13S	31E	MD	(Aubury, L. E. 05, p. 233; 08, p. 289; Bradley, W. W. 16a, p. 438.)
13	D	Kings River Canyon (Kenawyer?)		11	13S	31E	MD	(Watts, W. L. 93a, p. 217.)
		Kneiper: see Neiper						
		McKinsey: see Painter						
14	D	Mount Sterling		10	12S	23E	MD	(Aubury, L. E. 05, p. 230; 08, p. 287.)
15	C	Neiper (Kneiper)		34	11S	23E	MD	Produced prior to 1890; 80 ft. of shafts and drifts. (Goldstone, L. P. 90, p. 194.)
16	B	Painter (McKinsey?)	Imperial Copper Co., Clovis, Calif. (1917)	33	11S	21E	MD	Vein said to be 4-7 ft. wide; shafts 150, 110, and 80 ft.; other workings, 160 ft. (Aubury, L. E. 05, p. 225; 08, p. 278; Bradley, W. W. 16a, p. 438; Forstner, W. 08, p. 747.)

FRESNO COUNTY—Continued

Number	Class by production	Name of deposit	Name of owner or operator	Location Sec.	T.	R.	B. & M.	Remarks and references
17	C	Post Oak	W. Stammers, Selma, Calif. (1934)	29	12S	25E	MD	Copper mine?
18	D	Sunset		35	11S	23E	MD	150 ft. of workings. (Aubury, L. E. 05, p. 232; 08, p. 288.)
19	D	Terrill		16, 17	12S	25E	MD	(Aubury, L. E. 05, p. 233; 08, p. 288.)
20	C	Uncle Sam	W. C. Luce, Trimmer, Calif. (1916)	3	12S	29E	MD	Magnetite and bornite; workings, 90 ft.; 30-ft. shaft; 11 tons said to have been shipped to Selby smelter about 1916, returned almost $100 a ton, 15% Cu. No record in U. S. Bureau of Mines. (Bradley, W. W. 16a, p. 438.)
21	D	Wabash Mining Co.		2, 3 10, 11	12S	23E	MD	Near Copper King, 800 ft. of workings. (Aubury, L. E. 05, p. 230; 08, p. 287.)

GLENN COUNTY

Number	Class by production	Name of deposit	Name of owner or operator	Location Sec.	T.	R.	B. & M.	Remarks and references
1	D	Black Buttes		30, 31	22N	8W	MD	Cuprite in bunches, but no vein. (Aubury, L. E. 05, p. 132; 08, p. 159.)
2	D	Brisco (Hudibras)		1, 2 11, 12 13	19N	7W	MD	"Indications". (Aubury, L. E. 05, p. 131; 08, p. 158.)
		Hudibras: see Brisco						
3	D	Knight		18, 19	19N	6W	MD	"Indications". (Aubury, L. E. 05, p. 132; 08, p. 158.)
4	D	Lehour		6	18N	6W	MD	Native copper; adit 200 ft. in serpentine. (Aubury, L. E. 05, p. 132; 08, p. 159.)
5	D	St. John		18	18N	6W	MD	"Indications". (Aubury, L. E. 05, p. 132; 08, p. 158.)

HUMBOLDT COUNTY

Number	Class by production	Name of deposit	Name of owner or operator	Location Sec.	Location T.	Location R.	Location B. & M.	Remarks and references
*1	C		H. T. Weaver, Orleans, Calif. (1942)		6N?	4E?	H	Silver mine.
2	D	Copper Bluff	A. W. Scott, Happy Camp, Calif. (1943)	2	8N	4E	H	Zinc-copper prospect; O'Brien (oral comm.) says sphalerite close to surface. Discovered about 1942. (O'Brien, J. C. 43, pp. 79, 326.)
		Copper Glance: see Horse Mountain						
3	D	Crimson		8	2S	1E	H	Copper mine; prospect holes; 80 acres patented. (Aubury, L. E. 08, p. 152; Laizure, C. McK 25b, p. 305; Lowell, F. L. 16a, p. 399.)
4	B	Horse Mountain (Copper Glance, Humboldt Copper)	H. T. Weaver, Eureka, Calif. (1940)	33, 34	6N	4E	H	Copper mine; chalcopyrite in diorite, chalcocite in schist and diorite, bornite in schist, native copper in gabbro, reported. Underground workings, 7000 ft. (Averill, C. V. 41a, pp. 507-508; Laizure, C. McK 25b, p. 306; Lowell, F. L. 16a, pp. 396-398; Neale, W. G. 27, p. 489; Pabst, A. 38, p. 28; Rand, L. H. 31, p. 584; Weed, W. H. 20, p. 478.)
		Humboldt Copper: see Horse Mountain						
		La Perin: see Red Cap Creek						
5	D	Rainbow		12, 13 19, 30, 32	1S 1S	1W 1E	H H	Copper mine; trenches across 100-ft. mineralized zone. (Aubury, L. E. 08, p. 152; Laizure, C. McK 25b, p. 305; Lowell, F. L. 16a, p. 399.)
		Red Cap: see Red Cap Creek						
6	D	Red Cap Creek (La Perin, Red Cap, Sky Chief)	A. M. Johnson, Los Angeles, Calif. (1943)	29	10N	6E	H	Copper prospect; in 1880 considerable work was done to find the lode; so far evidently only rich float has been found; ore thought to lie on serpentine-diorite contact. (Aubury, L. E. 05, p. 127; 08, p. 151; Crawford, J. J. 94, p. 66; Hershey, O. H. 08a, pp. 429-430; Laizure, C. McK 25b, p. 305; McGregor, A. 90a, p. 207; O'Brien, J. C. 43, p. 79; Pabst, A. 38, p. 28.)
7	D	Red Lasseck		25	1S	5E	H	Oxidized copper minerals in serpentine. (Aubury, L. E. 08, p. 152.)
		Ruby: see Sweet Home						
		Sky Chief: see Red Cap Creek						
*8	C	Stewart	Stewart Bros., Orleans, Calif. (1942)					Gold mine; also silver.
9	C	Sweet Home (Ruby)		28	6N	4E	H	Under Horse Mountain Copper Co. was consolidated with Ruby; four adits; drifts, 230 ft. (Laizure, C. McK 25b, p. 305; Lowell, F. L. 16a, p. 397; Neale, W. G. 27, pp. 489-490; Rand, L. H. 31, p. 584.)
10	D	Vance	H. Vance, Eureka, Calif. (1924)	24	3S	3E	H	Copper mine; also pyrite. (Laizure, C. McK 25b, p. 305.)

* Not shown on map because of lack of definite location.

IMPERIAL COUNTY

Number	Class by production	Name of deposit	Name of owner or operator	Location				Remarks and references
				Sec.	T.	R.	B. & M.	
*1	C		C. Kirtch & B. Gunn, Glamis, Calif. (1942)	Approx.	12S	18E	SB	Lead-silver mine; also gold.
*2	C		Prewitt & McMahon, Picacho, Calif. (1909)	Approx.	14S	23E	SB	Copper mine?
3	B	American Girl	O'Brian Mines Co., Inc., Grosse Point Farms, Mich. (1939); Ogilby, Calif. (1941)	17	15S	21E	SB	Gold mine; concentrates contained 38% Cu. Accounts for most of the copper produced in Imperial County. (Sampson, R. J. 42, pp. 113-114.)
4	C	Blossom	L. C. Stubbins, Ogilby, Calif. (1939)	19	15S	21E	SB	Gold mine, 5 mi. NE of Ogilby. (Sampson, R. J. 42, p. 114.)
5	D	Butterfly and Pinto		35, 36	13S	22E	SB	
*6	D	Campbell	G. Campbell, Seeley, Calif. (1941)		15S	9E	SB	Copper mine; oxidized minerals; 15 mi. NW of Coyote Wells. (Sampson, R. J. 42, p. 111; Tucker, W. B. 26a, p. 252.)
7	D	Cave Man	E. B. Dykes, Riverside, Calif. (1941)	26	12S	20E	SB	Copper mine; mineralization on quartzite-schist contact; 40-ft. adit. (Sampson, R. J. 42, p. 111; Tucker, W. B. 26a, p. 252.)
*8	C	Danube	Danube Mining Co., Ogilby, Calif. (1937)	Approx.	15S	21E	SB	Gold mine; also silver.
*9	C	Drifted Snow	E. L. Akin, Ogilby, Calif. (1937)	Approx.	15S	21E	SB	Gold mine; also silver; 4 mi. NE of Ogilby.
*10	D?	Gaviland	N. M. Imbertson, 650 North Ave. 48, Los Angeles, Calif. (1943)					
11	C	Golden Cross	United Mine Co., Ogilby, Calif. (1914)	1, 12	15S	20E	SB	Gold mine; also silver; veins in schist. (Sampson, R. J. 42, p. 120.)
		Golden Queen: see Queen						
12	C	Good Luck and Gunsight	Harrison, Patton, and Walker, Ogilby, Calif. (1927)	1, 12 6, 7	15S 15S	20E 21E	SB SB	Gold mine; also silver.
*13	C	Gun Sight & Apache 7 and 2	Littlejohn & Johnson, Ogilby, Calif. (1926)	Approx.	15S	21E	SB	Gold mine.

*14	C	Marcella	Marcella Mining Co., Niland, Calif. (1916)	Approx.	9S	15E	SB	Lead-silver mine; also gold.
15	C?	Picacho		1	14S	22E	SB	Wide belt of copper stains in shear zone in mineralized schist; 5 shafts, 50-75 ft. (Sampson, R. J. 42, pp. 111-112; Tucker, W. B. 26a, p. 252.)
16	C	Queen (Golden Queen)	C. Walker, Ogilby, Calif. (1941)	1, 12	15S	20E	SB	Gold mine; also silver. (Sampson, R. J. 42, p. 120.)
		Sovereign: see Sovereign Grant						
17	C	Sovereign Grant	Sovereign Development Co., Ogilby, Calif. (1940)	6, 7	15S	21E	SB	Gold mine; also silver. (Sampson, R. J. 42, p. 125.)
18	C	Volunteer group	D. J. Kane, Brawley, Calif. (1941)	23, 26	12S	20E	SB	Copper mine (malachite and azurite along fractures in monzonite); shafts 70 and 10 ft.; small leaching operation in 1926. (Sampson, R. J. 42, p. 112; Tucker, W., 26a, p. 253.)

* Not shown on map because of lack of definite location.

INYO COUNTY

Number	Class by production	Name of deposit	Name of owner or operator	Location				Remarks and references
				Sec.	T.	R.	B. & M.	
*1	C		R. L. Franklin, Big Pine, Calif. (1942)	Approx.	10S	34E	MD	Lead-silver mine.
*2	C		L. Warnken, Jr., Keeler, Calif. (1943)	Approx.	16S	38E	MD	Lead-silver mine.
*3	C	Alturas	F. Barbour, Tecopa, Calif. (1912)	Approx.	20N	8E	SB	Lead-silver mine; also gold.
4	C	American	J. W. Stocker, Death Valley Junction, Calif. (1938)	5	20N	5E	SB	Copper-gold-silver mine. Shaft, 50 ft.; adit, 175 ft.; drifts, 80 ft.; on narrow vein with silver, copper, and gold. Said to have produced $10,000. Located 1902. (Tucker, W. B. 38a, p. 427, pl. 3; Waring, C. A. 19, p. 71.)
5	C	Anthony (Gold Bug)	S. H. Reynolds, Darwin, Calif. (1909)	12	22S	44E	MD	Gold mine; also silver, lead. (Tucker, W. B. 38a, p. 381.)
6	C	Anton and Pabst (Inyo)	J. C. Anton, Lone Pine, Calif. (1916)	4	16S	40E	MD	Copper mine; small production; 20-ft. adit. (Aubury, L. E. 08, p. 306; Tucker, W. B. 26b, p. 463; 38a, pl. 3; Waring, C. A. 19, p. 71.)
*7	C	Arcturus (Ibex)	Ibex Spring Mining Co., Tecopa, Calif. (1936)		20N	5E	SB	Lead-silver-zinc mine. (Tucker, W. B. 38a, p. 473.)
*8	C	Argus Copper	Argus Copper Co., Trona, Calif. (1919)		20S	42E	MD	Copper mine; also silver, gold. (Tucker, W. B. 38a, p. 468.)
9	C	Argus Sterling	C. Becker, Darwin, Calif. (1923)	26	20S	41E	MD	Lead-silver mine; also gold. (Tucker, W. B. 38a, pp. 427, 468, pl. 3.)
		Ashford: see Golden Treasure						
*10	C	Base Metals Mining Co.	H. R. Link, Big Pine, Calif. (1918)	Approx.	10S	37E	MD	Lead-silver mine.
11	C	Baxter (Jack Baxter)	J. P. Madison (1927)	3	23N	7E	SB	Lead-silver mine; also gold. (Tucker, W. B. 38a, pp. 427, 468, pl. 3.)
*12	C	Bean-Smith	R. C. Spear, Keeler, Calif. (1909)	Approx.	16S	39E	MD	Lead mine.
13	C	Belmont	Hunter Estate, Lone Pine, Calif. (1947)	19	16S	39E	MD	Lead-silver-copper mine. (Tucker, W. B. 38a, pp. 428, 468.)
*14	C	Berry Hill	C. L. Berryhill, Keeler, Calif. (1911)	Approx.	16S	39E	MD	Lead-silver mine.
*15	C	Big Four	S. Ness, Panamint Springs, Calif. (1944)	Approx.	19S	44E	MD	Zinc-lead-silver mine; also gold.
16	C	Big Horn (Big Horne)	S. R. Spear, Lone Pine, Calif. (1939)	35?	14S	37E	MD	Lead-silver-gold mine. (Tucker, W. B. 38a, p. 383, pl. 3.)

		Big Horn: see Honolulu—Big Horn						
		Big Silver: see Essex						
		Big Wedge: see Monte Carlo						
*17	C	Birthday	J. E. Brown, Independence, Calif. (1913)		23S	41E	MD	Gold mine. (Tucker, W. B. 38a, p. 469.)
		Bishop Creek Mining Co.: see Cardinal						(Tucker, W. B. 38a, p. 470.)
*18	C	Black Cap	Lemke Bros., Laws, Calif. (1934)	Approx.	7S	37E	MD	Lead-silver mine; 6 mi. E. of Deep Springs Ranch.
19	C	Black Eagle	National Consolidated Mines Co., Los Angeles, Calif. (1938)	15?	13S	36E	MD	Lead-silver-gold mine. (Tucker, W. B. 38a, p. 384, pl. 3.)
20	C	Blue Dick	H. Lang, Tecopa, Calif. (1913)	18?	20N	8E	SB	Lead mine; also silver. (Tucker, W. B. 38a, p. 469, pl. 3.)
21	C	Blue Jay	A. F. Mairs, Big Pine, Calif. (1915)	15?	15S	40E	MD	Malachite and chalcocite on granite-limestone contact; adit, 100 ft.; winze, 35 ft. (Aubury, L. E. 08, p. 310; Tucker, W. B. 26b, p. 463; Waring, C. A. 19, p. 71.)
		Blue Monster: see Monster						
		Brown Monster: see Reward						
22	C	Bull Domingo (Domingo Mining Co.)	P. N. Johnson, Long Beach, Calif. (1938)	15	6S	35E	MD	Lead-silver mine. (Tucker, W. B. 38a, pp. 429, 469, pl. 3.)
23	C	Buster Brown	H. Goodwin, Trona, Calif. (1936)	8?	22S	45E	MD	Gold mine; also silver. (Tucker, W. B. 38a, p.388, pl. 3.)
24	B	Butte group	Tonopah Banking Corp., Beatty, Nevada (1929)	16	15S	41E	MD	Copper mine; also lead; adits, 300 ft.; 100 tons ore shipped 1912; 24% Cu, $10 Au and Ag. (Tucker, W. B. 26b, p. 463; 38a, p. 3; Waring, C. A. 19, p. 71.)
		California Queen: see Copper Queen						
25	C	Carbonate (Carbonate Lead Mining Co.; see also Queen of Sheba)	New Sutherland Divide Mining Co., Mills Bldg., San Francisco, Calif. (1948)	20	22N	1E	SB	Lead-silver mine; also gold. (Tucker, W. B. 38a, pp. 430, 470, pl. 3.)
26	B	Cardinal (Wilshire, Bishop Creek)	Cardinal Gold Mining Co., Bishop, Calif. (1940); Cardinal Gold Mining Co., 927 S. 4th St., Los Angeles, Calif. (1937)	30	8S	31E	MD	Gold mine; also silver, lead; production recorded 1934-38, probably gold concentrates. (Symons, H. H. 37, p. 144; Tucker, W. B. 38, p. 10; 38a, p. 470, pl. 3.)
27	C	Cashier (Harrisburg)	W. E. Price, Los Angeles, Calif. (1915)	18?	18S	45E	MD	Gold mine; also silver, lead. (Tucker, W. B. 38a, p. 391, pl. 3.)
28	B	Cerro Gordo	Cerro Gordo Mines Co., San Jose, Calif. (1938)	13	16S	38E	MD	Lead-silver-zinc mine; also gold, copper; production recorded 1912-44, but not continuous. (Symons, H. H. 35, p. 269; Tucker, W. B. 38a, pp. 431, 470.)

INYO COUNTY—Continued

Number	Class by production	Name of deposit	Name of owner or operator	Location Sec.	T.	R.	B. & M.	Remarks and references
		Cerro Gordo Extension: see Royal						
		Chalmers: see Westgard						
		Chambers: see Silver Rule, San Bernardino County						
29	C	Chloride Cliff (McCrea group, Old Mill)	L. McCrea, Beatty, Nevada (1942)	28?	30N	1E	SB	Lead-silver mine; also gold. (Tucker, W. B. 38a, pp. 391, 470, pl. 3.)
30	C	Christmas Gift	L. D. Skinner, Darwin, Calif. (1926)	11	19S	40E	MD	Lead mine; also silver gold. (Kelley, V. C. 38, p. 554, pl. 7; Tucker, W. B. 38a, p. 470.)
*31	C	Chrysopolis	J. D. Black, Big Pine, Calif. (1928)	Approx.	10S	37E	MD	Copper mine?
32	C	Cleveland	M. D. Mears, Big Pine, Calif. (1941)	17	10S	34E	MD	Gold mine; also silver. (Tucker, W. B. 38a, p. 392, pl. 3.)
*33	C	Clipper		Approx.	10S	34E	MD	Copper mine.
*34	C	Collegiate	Crowell Mining & Milling Co., Van Nuys, Calif. (1936)	Approx.	30N	1E	SB	Lead-silver mine; also gold.
*35	C	Collina	G. Probasco, Shoshone, Calif. (1928)	Approx.	21N	7E	SB	Zinc-lead-silver mine.
*36	C	Collins	J. J. Collins, Bishop, Calif. (1918)	Approx.	7S	34E	MD	Lead-silver mine.
37	C	Colorado (Utacala group, Zinc Hill)	Combined Metals Production Co., Salt Lake City, Utah (1943)	36	18S	41E	MD	Zinc-lead-silver mine. (Merrill, C. W. 43, p. 248; Tucker, W. B. 38a, p. 470; 43a, p. 120.)
38	B	Columbia No. 2	Shoshone Mines, Inc., Shoshone, Calif. (1944)	15	20N	8E	SB	Lead-zinc mine.
39	C	Columbia (now part of Darwin Mines)		30	19S	41E	MD	Lead mine. (Kelley, V. C. 38, p. 561, pl. 7; Tucker, W. B. 38a, pl. 3 .)
40	C	Commetti (Fish Springs Hill)	LeRoi Smith, Big Pine, Calif. (1941)	7, 18	10S	34E	MD	Gold mine; also lead, silver. (Tucker, W. B. 38a, pp. 393, 470.)
41	D?	Copper Bar		15	23N	3E	SB	Copper mine. (Tucker, W. B. 38a, pl. 3.)
		Copper Bell: see Ubehebe						

42	D?	Copper Blue Consolidated		20	24N	3E	SB	Copper mine. (Tucker, W. B. 38a, pl. 3.)
*43	C	Copper Clame (sic) group	Gold Bottom Mines, Inc., Bakersfield, Calif. (1936)	Approx.	24S	43E	MD	Copper mine; also lead, silver, gold.
44	D?	Copper Glance		27	24N	3E	SB	Copper mine. (Tucker, W. B. 38a, pl. 3.)
45	C	Copper Grand		13	19S	40E	MD	Granite-limestone contact; 20 tons ore shipped. (Goodyear, W. A. 88, p. 226.)
46	D	Copper King	R. McMahan, Bishop, Calif. (1926)	12?	15S	40E	MD	Oxides and sulphides of copper on granite-limestone contact; two adits, each 40 ft.; drifts, 50 ft. (Tucker, W. B. 26b, p. 464; 38a, pl. 3; Waring, C. A. 19, p. 71.)
47	D	Copper King and Star		7?	15S	41E	MD	Copper mine; shaft, 60 ft.; drift, 20 ft. (Aubury, L. E. 08, pp. 309-310; Tucker, W. B. 26b, p. 464; 38a, pl. 3.)
48	D?	Copper Matte Consolidated		20?	24N	3E	SB	Copper mine. (Tucker, W. B. 38a, pl. 3.)
49	D?	Copper Oxide		26?	24N	3E	SB	(Tucker, W. B. 38a, pl. 3.)
50	D	Copper Point		20	8S	36E	MD	Shaft, 10 ft.; granite-limestone contact. (Aubury, L. E. 05, p. 249; 08, p. 306.)
51	B	Copper Queen (California Queen, Gold Bottom, Slate Range)	Gold Bottom Mines, Inc., Pasadena, Calif. (1944)	6	24S	44E	MD	Copper-gold-lead-silver mine; also zinc. (Tucker, W. B. 38a, p. 471, pl. 3.)
		Copper Queen: see Oasis						
52	D?	Copper Summit		35	15S	37E	MD	Copper mine. (Tucker, W. B. 38a, pl. 3.)
53	D	Copper Tail		20	8S	36E	MD	Shaft, 40 ft. (Aubury, L. E. 05, p. 249; 08, p. 306.)
54	C	Coso (Coso Copper, Fernando)	J. O. Lee, Darwin, Calif. (1917)	24	19S	40E	MD	Copper-lead-silver mine; shaft, 175 ft., on 4-ft. fissure vein in limestone; 50 tons shipped 1916; more than 100 ft. of drifts. (Tucker, W. B. 26b, p. 464; 38a, pp. 440; Kelley, V. C. 38, p. 560, pl. 8; Waring, C. A. 19, p. 72.)
55	C	Curran	J. E. Curran, San Bernardino, Calif. (1918)	11	21S	45E	MD	Gold mine; also silver. (Sampson, R. J. 32, pp. 366-368; Tucker, W. B. 38a, pp. 394, 471.)
56	C	Custer	F. H. Long, Altadena, Calif. (1940)	28, 29	12S	36E	MD	Lead-silver mine. (Tucker, W. B. 38a, pp. 435, 470.)
°57	D	Custer	Long & Grimes, Pasadena, Calif. (1938)	24	19S	40E	MD	Lead-silver-copper mine. (Aubury, L. E. 05, p. 246; 08, p. 314; Tucker, W. B. 38a, pp. 435, 470.)
°58	C	Daily & Breen	Daily & Breen, Independence, Calif. (1913)	Approx.	14S	36E	MD	Copper mine?
	B	Darwin Mines: shown on map as Columbia, Defiance, Essex, Independence, Lane, Lucky Jim, Promontory, and Thompson mines, which see	Anaconda Copper Co., New York, N. Y. (1937)					

INYO COUNTY—Continued

Number	Class by production	Name of deposit	Name of owner or operator	Location: Sec.	T.	R.	B. & M.	Remarks and references
		Darwin - Keystone: see Keystone						
*59	C	Death Valley (Wonder)	Death Valley Mining Co., Tecopa, Calif. (1909)		17S	44E	MD	Gold mine. (Tucker, W. B. 38a, p. 471.)
		Death Valley-Wonder: see Death Valley						
60	C	Defense	L. D. Foreman and W. V. Skinner, Panamint Springs, Calif. (1948)	18	19S	42E	MD	Lead-silver mine; also gold.
61	C	Defiance (now part of Darwin Mines)	J. B. Anthony, Yermo, Calif. (1939)	14	19S	40E	MD	Lead-silver-zinc-tungsten mine; also gold. (Kelley, V. C. 38, pp. 557-558, pl. 7; Tucker, W. B. 38, p. 16; 43a, p. 118.)
62	C	Del Norte	Del Norte Mining Co., Mojave, Calif. (1943)	23?	17S	44E	MD	Gold mine; also silver. (Tucker, W. B. 38a, p. 471, pl. 3.)
63	D	Dodd's Springs: see also Trail mine		36	15S	41E	MD	(Aubury, L. E. 05, p. 246; 08, p. 304.)
		Domingo Mining Co.: see Bull Domingo						
64	C	Eclipse	R. A. Hacker, Darwin, Calif. (1939)	34	19S	42E	MD	Gold mine; also silver. (Tucker, W. B. 38a, p. 471.)
°65	C	Ella group	J. Brennan, Keeler, Calif. (1947)	13	16S	38E	MD	Lead mine; also gold, silver. (Tucker, W. B. 38a, pp. 437, 472, pl. 3.)
*66	C	Empire	J. H. Moffett, Independence, Calif. (1919)		10S	37E	MD	Lead-silver mine; also gold.
67	C	Essex (now part of Darwin Mines)	Anaconda Copper Co., New York, N. Y. (1947)	14	19S	40E	MD	Lead-silver mine. (Kelley, V. C. 38, pp. 556-557, pls. 6, 7.)
68	C	Essex (Big Silver)	Silver Mining Co., Los Angeles, Calif. (1928)	31	13S	38E	MD	Lead-silver mine; also gold. (Tucker, W. B. 38a, pl. 3; 40, p. 25.)
69	C	Estelle (see also Morning Star)	Estelle Mines Corp., Los Angeles, Calif. (1937)	23	16S	38E	MD	Lead-zinc-silver mine; tunnel 8100 ft. Apparently production includes that of several small mines under same management, as well as Cerro Gordo mine during some years. (Tucker, W. B. 38a, pp. 437-440, 472.)
70	D	Eureka		31, 32	11S	35E	MD	Gold-copper mine; oxidized copper minerals and galena, chrysocolla in quartz veins; 80-ft. shaft, 100 ft. of drifts.
*71	C	Eva Bell	T. K. Andreas, Bishop, Calif. (1901)	Approx.	7S	34E	MD	Lead-silver mine; also gold.

*72	C	Fairy Queen 1, 2, 3, 4	Mrs. E. T. O'Brien, Artesia, Calif. (1934)	Approx.	30N	1E	SB	Silver mine.
*73	C	Farrington	A. Farrington, Keeler, Calif. (1914)	Approx.	16S	38E	MD	Lead-silver mine.
		Fernando: see Coso						
		Fish Springs Hill: see Commetti						
*74	C	Fitzgerald	J. H. Fitzgerald, Independence, Calif. (1913)	Approx.	13S	36E	MD	Copper mine?
*75	C	Four Leads	E. H. Hughes, Trona, Calif. (1927)	Approx.	24S	43E	MD	Copper mine.
*76	C	Four Metals Smelt	A. R. Short, Keeler, Calif. (1911)	Approx.	16S	39E	MD	Lead-silver producer. Possibly smelter production from Cerro Gordo mine.
*77	C	Franklin D. Roosevelt	J. W. Wightman, Lone Pine, Calif. (1935)	Approx.	15S	37E	MD	Lead mine.
*78	C	Frazier	C. H. Frazier, Zabriskie, Calif. (1917)	Approx.	20N	8E	SB	Lead-silver mine; also gold.
*79	C	Free & Easy	C. L. Evans, Los Angeles, Calif. (1943)	Approx.	24N	3E	SB	Lead-silver mine; also gold.
*80	C	Freeze	Ferguson-Johnson et al.	Approx.	10S	34E	MD	Lead-silver mine; also gold.
81	C	Furnace Creek		23	23N	3E	SB	Bingham Cons. Smelter records, 1907.
*82	C	Gehrig	P. Gehrig, Keeler, Calif. (1912)	Approx.	16S	39E	MD	Gold mine; also silver.
83	C	Gem-New Discovery (Jail Canyon, New Discovery-Gem)	Gem Mines, Inc., Los Angeles, Calif. (1941)	16	20S	44E	MD	Gold mine; also lead, silver. (Tucker, W. B. 38a, pp. 413, 476, pl. 3; 40, p. 24.)
		Gibraltar: see Honolulu - Big Horn						
*84	C	J. A. Gilbert (1914)	J. A. Gilbert, Zabriskie, Calif.	Approx.	20N	8E	SB	Copper mine?
*85	C	Givens	W. A. Givens, Keeler, Calif. (1911)	Approx.	16S	38E	MD	Lead-silver; also gold.
*86	C	Gladstone	C. Brown, Shoshone, Calif. (1939)	Approx.	20N	5E	SB	Lead-silver mine; also gold.
*87	C	Gold Belle	Gold Belle Mines Co., Zurich via Shoshone, Calif. (1935)	Approx.	20N	5E	SB	Lead-silver mine

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Number	Class by production	Name of deposit	Name of owner or operator	Location Sec.	T.	R.	B. & M.	Remarks and references
88	C	Gold Bird	E. O. Graves, Glendora, Calif. (1941)	12?	18S	44E	MD	Lead mine. (Tucker, W. B. 38a, pl. 3.)
		Gold Bottom: see Copper Queen						
		Gold Bug: see Anthony						
89	C	Gold Hill	James & Dodson, Lone Pine, Calif. (1940)	14?	22S	46E	MD	Gold mine; also lead, silver. (Tucker, W. B. 38a, p. 472, pl. 3.)
*90	C	Gold Ring	R. Weir, Trona, Calif. (1935)	Approx.	21S	41E	MD	Copper mine?
*91	C	Golden	M. E. Franklin, Los Angeles, Calif. (1944)	Approx.	20S	42E	MD	Lead-silver mine; also gold.
*92	C	Golden Circle	W. R. McCrea, Beatty, Nevada (1936)	Approx.	30N	1E	SB	Copper mine?
93	D	Golden Eagle group	Miss Louise Grantham, 809 E. 6th St., Ontario, Calif. (1948)	23	22S	46E	MD	Gold-silver-copper mineralization; 40-ft. tunnel, 10-ft. winze. (Written communication, L. A. Norman Jr., 1948.)
*94	C	Golden Gate (Golden Gate Lease?)	T. Casey, Keeler, Calif. (1911)	--------	20S	40E	MD	Gold mine. (Tucker, W. B. 38a, p. 473.)
*95	C	Golden Gate Lease (Golden Gate?)	E. B. Hausen, Keeler, Calif. (1914)	--------	20S	40E	MD	Gold mine.
*96	C	Golden Reef	Golden Reef Mining Co., Los Angeles, Calif. (1937)	--------	16S	38E	MD	Gold mine.
97	C	Golden Treasure (Ashford)	H. Ashford, Shoshone, Calif. (1942)	3	21N	3E	SB	Gold-lead-silver mine. (Tucker, W. B. 38a, p. 473, pl. 3.)
*98	C	Gordon	T. A. Gordon, Keeler, Calif. (1913)	Approx.	16S	38E	MD	Lead-silver mine; also gold.
99	C	Gray Eagle	Mrs. S. P. Griffith, Bishop, Calif. (1940)	10	7S	34E	MD	Gold mine; also silver. (Knopf, A. 18, p. 119.)
*100	C	Green Gold	V. A. Colvin, Beatty, Nevada (1939)	Approx.	30N	1E	SB	Copper mine?
101	C	Green Monster	M. Luther, San Jose, Calif. (1925)	1, 2	13S	35E	MD	Copper mine; adit, 300 ft.; crosscuts, 50 and 40 ft.; produced 1903-06. (Aubury, L. E. 05, p. 249; 08, p. 306; Tucker, W. B. 26b, p. 464; Waring, C. A. 19, p. 72.)
102	C	Greenwater	----------------------------	29	24N	5E	SB	Copper mine. (Tucker, W. B. 26b, p. 464.)

*103	C	Grimes & Sexton	Grimes & Sexton, Trona, Calif. (1920)	Approx.	23S	43E	MD	Lead-silver mine; also gold.
104	B	Gunsight & Noonday	Tecopa Cons. Mining Co., Los Angeles, Calif. (1939)					Two separate mines, operated jointly.
		Gunsite (Gunsight)		9	20N	8E	SB	Lead-silver-zinc mine; also gold. (Tucker, W. B. 26b, p. 485; 38a, pp. 440, 472, pl. 3.)
		Noonday		15	20N	8E	SB	Lead-silver mine; also gold. (Tucker, W. B. 38a, pp. 448-450, 477, pl. 3.)
		Harrisburg: see Cashier						
*105	C	Henrietta	J. McCloud, Darwin, Calif. (1914)	Approx.	19S	40E	MD	Lead-silver mine.
106	D	Hessen Clipper		15	15S	40E	MD	Copper silicates and carbonates; 50-ft. tunnel; 40-ft. shaft. (Written communication, L. A. Norman Jr., 1947.)
107	C	Honolulu—Big Horn (Gibraltar)	F. Long, Altadena, Calif. (1944)	31	22S	45E	MD	Zinc-lead-silver mine; also gold. (Tucker, W. B. 38a, p. 472.)
*108	C	Hook	B. A. Hook, Darwin, Calif. (1924)	Approx.	19S	40E	MD	Lead-silver mine.
*109	C	Howard	H. W. Darling, Owenyo, Calif. (1918)	Approx.	14S	36E	MD	Lead-silver mine; also gold.
*110	C	Hughes Lead	Hughes & Franklin, Independence, Calif. (1942)	Approx.	13S	36E	MD	Lead-silver mine; also gold.
*111	C	Hunter	W. L. Hunter, Independence, Calif. (1918)	Approx.	13S	36E	MD	Lead-silver mine.
*112	C	Huntington	F. D. Bailey, Bishop, Calif. (1913)	Approx.	7S	34E	MD	Copper mine?
		Ibex: see Arcturus						
		Ignacio: see Ygnacio						
*113	C	Inden Lead & Silver Mining Co.	B. S. Edwards (1913)	Approx.	16S	38E	MD	Lead-silver mine; also gold.
114	C	Independence (now part of Darwin Mines)	Wagner Assets Realization Co., Chicago, Illinois (1938)	14	19S	40E	MD	Lead-silver-tungsten mine. (Kelley, V. C. 38, p. 556, pl. 7; Tucker, W. B. 38, p. 16.)
		Inyo: see Anton and Pabst						
*115	C	Inyo County Bank	Inyo County Bank (1918)	Approx.	9S	34E	MD	Lead-silver mine.
116	D	Inyo Copper Mines and Smelter Co.		26	15S	41E	MD	Considerable development work. (Aubury, L. E. 08, p. 307; Waring, C. A. 19, p. 73.)
*117	C	Inyo Silver-Lead Smelting Co.	Inyo Silver-Lead Smelting Co. (1918)	Approx.	19S	40E	MD	Lead-silver mine?

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Number	Class by production	Name of deposit	Name of owner or operator	Location: Sec.	T.	R.	B. & M.	Remarks and references
*118	C	Irwin	J. A. Irwin, Keeler, Calif. (1909)	Approx.	16S	38E	MD	Lead-silver mine.
		Jack Baxter: see Baxter						
		Jail Canyon: see Gem—New Discovery						
*119	C	Johnson & Williams	Johnson & Williams (1918)	Approx.	13S	36E	MD	Copper mine?
120	C	Jumbo	C. Johnson, Independence, Calif. (1938?)	17	17S	39E	MD	Copper-lead-silver-gold mine, irregular lenses in limestone; 4 tons per day shipped by pack train (1915) ran 8% Cu, 15% Pb, 4 oz. Ag; adits 240 and 150 ft.; 40-ft. winze. (Tucker, W. B. 26b, p. 464; 38a, p. 402; Waring, C. A. 19, p. 73.)
121	C	Keane-Wonder	Keane Wonder Gold Mining Co., Las Vegas, Nevada (1942)	6 31	29N 30N	1E 1E	SB SB	Gold mine, with lead and copper. (Tucker, W. B. 38a, p. 402.)
122	C	Keeler (Kruger)	Keeler Gold Mines, Inc., Los Angeles, Calif. (1938)	23	17S	38E	MD	Gold mine; also lead, silver. (Tucker, W. B. 38, p. 10; 38a, p. 403, pl. 3.)
*123	C	Kespirt	C. Kespirt, Big Pine, Calif. (1923)	Approx.	10S	37E	MD	Lead-silver mine; also gold.
124	C	Keystone group (Darwin-Keystone)	A. A. Rubel, Piru, Calif. (1938)	19 24	19S 19S	41E 40E	MD MD	Copper mine; also lead, silver, gold. (Kelley, V. C. 38, p. 553, pl. 7; Tucker, W. B. 38a, pp. 426, 435-436.)
*125	C	King Henry	W.J. Lange, Brown, Calif. (1942)	Approx.	24S	37E	MD	Lead mine.
126	D	Kingman	----------	36	19S	40E	MD	Granite-limestone contact; two adits, 100 ft. each. (Aubury, L. E. 05, p. 245; 08, p. 301.)
		Kruger: see Keeler						
*127	C	Kunze	A. Kunze, Shoshone, Calif. (1929)	Approx.	21N	5E	SB	Copper mine.
128	C	La Moine (Le Moigne)	Buckhorn Humboldt Mining Co., Beatty, Nevada (1927)	36	16S	44E	MD	Lead-silver mine; also gold. (Tucker, W. B. 38a, p. 443, pl. 3.)
129	C	Lane (Last Chance No. 2, Sorba) (now part of Darwin Mines)	Wagner Assets Realization Corp., Chicago, Illinois (1938)	13	19S	40E	MD	Lead-silver mine. (Kelley, V. C. 38, p. 559, pl. 7; Tucker, W. B. 38a, pp. 442, 475, pl. 3.)
		Last Chance: see Lane						
*130	C	Lead	E. H. Hughes, Trona, Calif. (1927)	Approx.	23S	43E	MD	Lead-silver mine; also gold.
131	C	Lead King	G. Lippencott, Keeler, Calif. (1944)	13	15S	40E	MD	Lead-silver mine; also gold.

		Lead Queen: see Royal group						
132	C	Leary	Desert Miners, Lone Pine, Calif. (1943)	24?	16S	37E	MD	Zinc-lead-silver mine; also gold.
133	C	Lee	V. Couser, Darwin, Calif. (1938)	26	17S	40E	MD	Silver-lead-zinc mine. (Tucker, W. B. 38a, pp. 443, 475, pl. 3.)
		Le Moigne: see La Moine						
*134	C	Lestro	C. Brown, Shoshone, Calif. (1933)	Approx.	20N	5E	SB	Lead-silver mine; also gold.
*135	C	Lockie & Black	J. Black, Big Pine, Calif. (1914)	Approx.	10S	37E	MD	Copper mine?
136	C	Long John	Long John Mining Co., Lone Pine, Calif. (1939)	16, 21	15S	37E	MD	Lead-silver mine. (Tucker, W. B. 40, p, 26.)
*137	C	Lookout No. 1	J. Wiggington, Keeler, Calif. (1919)	Approx.	16S	39E	MD	Lead-silver mine.
138	D	Loretto (Loretta)	Loretto Mining Co., New York, N. Y. (1925)	16	8S	37E	MD	Copper mine; large body of oxide copper ore; 1800-ft. shaft (1907-15) sunk in attempt to reach sulphide zone, but vein pinched with depth. (Tucker, W. B. 26b, p. 464; Waring, C. A. 19, p. 73.)
*139	C	Lost Frenchman	D. Hansen, Keeler, Calif. (1911)	Approx.	16S	38E	MD	Lead-silver mine.
*140	C	Lucky Dog	G. H. Lewis, San Diego, Calif. (1940)	Approx.	16S	38E	MD	Lead mine.
141	C	Lucky Jim group (now part of Darwin Mines)	Wagner Estate Corp., Chicago, Illinois (1938)	11	19S	40E	MD	Lead-silver mine. (Kelley, V. C. 38, p. 554, pl. 7; Tucker, W. B. 38a, p. 444.)
*142	C	Madison	J. P. Madison, Trona, Calif. (1936)	Approx.	21S	45E	MD	Lead-silver mine; also gold.
143	C	Mammoth	C. Beauregard, Laws, Calif. (1940)	3	23S	41E	MD	Gold mine. (Tucker, W. B. 38a, p. 475, pl. 3.)
144	C	Mayflower group	Stewart & Lolly, Darwin, Calif. (1923)	14	16S	38E	MD	Lead-silver mine. (Tucker, W. B. 38a, p. 476.)
*145	C	McCabe	P. McCabe, Tecopa, Calif. (1918)	Approx.	20N	8E	SB	Lead-silver mine.
		McCrea group: see Chloride Cliff						
*146	C	McDonald	J. McDonald, Keeler, Calif. (1918)	Approx.	16S	39E	MD	Lead-silver mine.
*147	C	McMillan Bros.	McMillan Bros., Bishop, Calif. (1926)	Approx.	7S	34E	MD	Silver mine.
		Mineral Hill: see Swank						
148	C	Mineral Point (Sanger)	Bretz & Flynn Bros., Bishop, Calif. (1938)	13, 14 23, 24	7S	34E	MD	Lead-silver mine; also gold. (Tucker, W. B. 38a, p. 444.)

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Number	Class by production	Name of deposit	Name of owner or operator	Location				Remarks and references
				Sec.	T.	R.	B. & M.	
149	C	Minnietta (Minneatta, St. John)	Ralph Merritt, Independence, Calif. (1947)	33	19S	42E	MD	Lead-silver mine; also gold. (Tucker, W. B. 38a, pp. 426-427, 445, 476.)
*150	C	Mistake	J. P. Compton, Laws, Calif. (1926)	Approx.	7S	34E	MD	Lead-silver mine.
151	C	Modoc	Hearst Estate, San Francisco, Calif. (1948)	28	19S	42E	MD	Lead-silver mine; produced from tailings 1945-47. (Tucker, W. B. 38a, pp. 426-427, 445-447, 476.)
*152	C	Moltby	B. Moltby, Bishop, Calif. (1921)	Approx.	7S	34E	MD	Silver mine.
153	C	Monster (Blue Monster)	J. P. Fitting, Big Pine, Calif. (1916)	8	14S	38E	MD	Lead-silver mine. (Tucker, W. B. 38a, pp. 447, 476, pl. 3.)
154	C	Monte Carlo (Big Wedge, Mt. Whitney-Union	Keeler Gold Mines, Inc., Los Angeles, Calif. (1939)	14	14S	36E	MD	Lead-silver-gold mine. (Tucker, W. B. 38a, p. 457.)
155	C	Montezuma	E. Craft, Big Pine, Calif. (1943)	7	10S	35E	MD	Lead-zinc-silver mine; also gold. (Tucker, W. B. 38a, pp. 447, 476, pl. 3.)
*156	C	Moonlight	H. V. Pleikas, Trona, Calif. (1923)	Approx.	23S	43E	MD	Copper mine?
157	C	Morning Glory	H. P. Gower, Death Valley, Calif. (1939)	17, 18 19, 20	24N	3E	SB	Lead-silver mine. (Tucker, W. B. 38a, p. 476.)
158	C	Morning Star (see also Estelle)	Keeler Gold Mines, Inc., Los Angeles, Calif. (1938)	24	16S	38E	MD	Gold mine; also lead, zinc, silver. (Tucker, W. B. 38a, pp. 437-440, 472.)
		Mt. Whitney-Union: see Monte Carlo						
159	C	Mountain View	Broachman & Haws, Gibbon, Calif. (1913)	34	13S	37E	MD	Gold mine; also silver. (Tucker, W. B. 38a, pl. 3.)
160	D	Navajo Chief		36	15S	40E	MD	Copper mine; granite-limestone contact. (Aubury, L. E. 05, p. 245; 08, pp. 303-304; Tucker, W. B. 26b, p. 464; Waring, C. A. 19, p. 73.)
*161	C	Nellie H.	Strauss & Brown, Lone Pine, Calif. (1922)	Approx.	15S	37E	MD	Gold mine.
*162	C	New Cosomo	L. L. Brackitt, Darwin, Calif. (1914)	Approx.	19S	40E	MD	Lead-silver mine.
*163	C	New Deal	Lead Canyon Mining Co., Pacific Palisades, Calif. (1941)		23S	44E	MD	Lead-zinc mine; also silver. (Tucker, W. B. 38a, p. 476.)
		New Discovery: see Gem-New Discovery						

*164	C	New Era	McClellan & Crow, Big Pine, Calif. (1941)	Approx.	10S	34E	MD	Copper mine?
165	C	Newsboy	Newsboy Mining Co., Keeler, Calif. (1913)	19	16S	39E	MD	Lead-silver mine; also gold. (Knopf, A. 18, p. 117.)
		Noonday: see Gunsite and Noonday						
*166	C	Nute Knudson	N. Knudsen, Independence, Calif. (1909)	Approx.	13S	36E	MD	Copper mine?
167	D	Oasis (Copper Queen)	Oasis Copper Corp., New York, N. Y. (1925)	7	6S	37E	MD	Copper mine; 50-ft. shaft on granite-limestone contact; active in 1915. (Jenkins, O. P. 42, p. 324; Tucker, W. B. 26b, p. 464; 38a, pl. 3; Waring, C. A. 19, pp. 73-74.)
*168	C	Old Coso	C. R. Townsend, Keeler, Calif. (1910)	Approx.	20S	40E	MD	Lead-silver mine.
*169	C	Old Gold Mines	Old Gold Mines Co., Trona, Calif. (1941)	Approx.	22S	45E	MD	Lead-silver mine; also gold.
*170	C	Old Mill	Buckhorn, Humboldt, Calif. (1926)	Approx.	17S	44E	MD	Lead-silver mine; also gold.
		Old Mill: see Chloride Cliff						(Tucker, W. B. 38a, p. 391.)
171	C	Ophir	Engineers Exploration Co., Los Angeles, Calif. (1943)	18	24S	44E	MD	Lead-silver-zinc mine; also gold. (Tucker, W. B. 38a, p. 477, pl. 3.)
		Orion: see Stewart						
*172	C	Oversight	J. P. Madison, Ludlow, formerly Stagg, Calif. (1928)	Approx.	22S	47E	MD	Lead-silver mine; also gold.
173	C	Paddy Pride (Paddy's Pride)	Paddy Pride Silver Mines Co., Zabriskie, Calif. (1923)	13	21N	5E	SB	Lead-silver mine; also gold. (Tucker, W. B. 38a, p. 477, pl. 3.)
*174	C	Paloma claim	F. Barber, Tecopa, Calif. (1923)	Approx.	20N	8E	SB	Lead-silver mine; also gold.
*175	C	Panamint	F. Gray, Trona, Calif. (1940)		19S	44E	MD	Silver mine. (Tucker, W. B. 38a, p. 477.)
*176	C	Pay-Day	J. H. Foelkel, Bishop, Calif. (1935)	Approx.	6S	34E	MD	Lead-silver mine; also gold.
177	C	Pennsylvania	J. Carruthers (1942)	13	16S	37E	MD	Lead-silver mine. (Tucker, W. B. 38a, p. 477, pl. 3.)
		Perseverance: see San Lucas						
178	A	Pine Creek	U. S. Vanadium Corp., New York, N. Y. (1943)	31? 36?	6S 6S	30E 29E	MD MD	Tungsten mine; also copper, molybdenum, lead, zinc, silver, gold. (Tucker, W. B. 38a, p. 477, pl. 3.)
179	C	Poleta (Polita)	C. H. Olds, Bishop, Calif. (1941)	7, 8	7S	34E	MD	Gold-lead-silver mine. (Tucker, W. B. 38a, p. 414; 40, p. 24.)
		Polita: see Poleta						

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Number	Class by production	Name of deposit	Name of owner or operator	Location				Remarks and references
				Sec.	T.	R.	B. & M.	
*180	C	Priner		Approx.	10S	34E	MD	Copper mine?
181	C	Promontory (now part of Darwin Mines)		25	19S	40E	MD	Lead-silver mine. (Kelley, V. C. 38, p. 561, pl. 7; Tucker, W. B. 38a, p. 477.)
*182	C	Pyper	V. J. Pyper, Big Pine, Calif. (1909)	Approx.	6S	37E	MD	Copper mine.
183	C	Queen of the Mountains	Jack Carruthers, Swansea, Calif. (1947)	13	16S	37E	MD	Lead-silver mine.
184	C	Queen of Sheba (also see Carbonate)	New Sutherland Divide Mining Co., Mills Bldg., San Francisco, Calif. (1948)	20	22N	1E	SB	Lead-silver mine; also gold. (Tucker, W. B. 38a, pp. 430-431, 470.)
*185	C	Reid group	Shively, Petersen, & Hopkins, Keeler, Calif. (1937)	Approx.	16S	38E	MD	Lead-silver mine; also gold.
186	C	Reward (Brown Monster)	T. L. Bright, Owenyo, Calif. (1944)	3	14S	36E	MD	Gold mine; also lead, silver. (Tucker, W. B. 38a, p. 469.)
*187	C	Riff Raff	H. L. Eckloff, Keeler, Calif. (1940)	Approx.	16S	38E	MD	Lead-silver mine; also gold.
*188	C	Robin Hood		Approx.	16S	38E	MD	Lead-silver mine.
189	C	Mary Roper	M. Roper, Independence, Calif. (1918)	14?	13S	36E	MD	Iron mine (specular hematite); also gold. (Tucker, W. B. 38a, p. 425, pl. 3.)
*190	C	Rose & Galena	J. Cyty, Beatty, Nevada (1939)	Approx.	30N	1E	SB	Lead-silver mine; also gold.
*191	C	Ross	R. Horstmeier, Darwin, Calif. (1941)	Approx.	20S	40E	MD	Gold mine; also silver.
°192	C	Royal group (Cerro Gordo Extension, Lead Queen, Spear)	Cerro Gordo Extension Mining Co., Keeler, Calif. (1937)	13	16S	38E	MD	Lead-zinc-silver mine; also gold. (Tucker, W. B. 38a, pp. 433-434, 470.)
		St. John: see Minnietta						
		Sam Lucas: see San Lucas						
		Sanger: see Mineral Point						
193	C	San Lucas (Sam Lucas, Perseveranee)	J. Brennan, Keeler, Calif. (1947)	18	16S	39E	MD	Lead-silver-zinc mine; also gold; quartz veins with tetrahedrite. (Knopf, A. 18, p. 117; Tucker, W. B. 26b, p. 498; 38a, p. 452, pl. 3.)
194	D	San Rafael		5	20S	45E	MD	Lead-copper mine; granite-limestone contact. Located about 1915. (Sampson, R. J. 32, p. 359; Tucker, W. B. 26b, p. 465; 38a, pl 3; Waring, C. A. 19, p. 74.)

195	B	Santa Rosa	Santa Rosa Mining & Development Co., Keeler, Calif. (1938)	26, 35	17S	39E	MD	Lead-silver mine; also gold. (Tucker, W. B. 38a, p. 478.)
°196	D	Settle Up	-----	18	15S	41E	MD	Copper mine. (Tucker, W. B. 26b, p. 465; Waring, C. A. 19, p. 74.)
°197	C	Shafer	H. A. Shafer, Keeler, Calif. (1918)	Approx.	16S	38E	MD	Lead-silver mine.
		Silver Ball: see Skidoo						
		Silver Bell: see Skidoo						
°198	C	Silver Bow	Silver Bow Mining Co., Bishop, Calif. (1912)	Approx.	7S	34E	MD	Silver mine.
199	D	Silver Hill	-----	18	13S	36E	MD	Granite-limestone contact; 70-ft. adit. (Aubury, L. E. 05, p. 248; 08, p. 306)
		Silver Reef: see Ventura						
		Silver Rule: see under San Bernardino County						
200	C	Silverite	E. H. Hughes, Darwin, Calif. (1913)	19	8S	37E	MD	Lead-silver mine? (Tucker, W. B. 38a, pl. 3.)
201	C	Skidoo (Silver Ball, Silver Bell)	R. Journigan, Whittier, Calif. (1938)	24?	17S	44E	MD	Gold mine; also silver. (Tucker, W. B. 38a, p. 479, pl. 3.)
		Slate Range: see Copper Queen						
*202	C	Smuggler	Johns & Fitch, Trona, Calif. (1937)	Approx.	21S	42E	MD	Copper mine.
		Sorba: see Lane						
		Spear: see Royal group						
203	C	Speculator	H. Lang, Tecopa, Calif. (1919)	26, 27 34, 35	24N	3E	SB	Copper mine. (Tucker, W. B. 38a, p. 479.)
204	D	Stewart (Orion, Stewart-Wonder)	Jack Stewart, Darwin, Calif.; lessee, Clyde H. Kettering, 115 E. Golden Ave., Los Angeles, Calif. (1943)	10	21S	45E	MD	Lead-silver-tungsten mine. (Tucker, W. B. 38a, p. 479.)
		Stewart-Wonder: see Stewart						
205	C	Stockwell	Stockwell Gold Mining Co., Trona, Calif. (1942)	34?	23S	44E	MD	Gold mine; pyrite and a little chalcopyrite in vein. (Tucker, W. B. 38a, pp. 422, 479, pl. 3.)
		Sunset: see Ventura						
*206	C	Sure Contest	H. L. Eckloff, Keeler, Calif. (1937)	Approx.	16S	38E	MD	Lead-silver mine.

INYO COUNTY—Continued

Number	Class by production	Name of deposit	Name of owner or operator	Location				Remarks and references
				Sec.	T.	R.	B. & M.	
207	C	Surprise Package	E. C. Fries, Independence, Calif. (1942)	3, 4 9, 10	14S	36E	MD	Gold mine; also silver.
208	C	Swank (Mineral Hill)	R. W. Swank, Big Pine, Calif. (1938)	29	8S	36E	MD	Lead-silver mine. (Tucker, W. B. 38a, p. 476.)
209	C	Thompson (now part of Darwin Mines)		14	19S	40E	MD	Lead-silver mine. (Kelley, V. C. 38, p. 557, pl. 7; Tucker, W. B. 38a, p. 436.)
*210	D	Tibbals	Carl Tibbals, 2322 Marshall Way, Sacramento, Calif. (1943)					
*211	C	Tip Top	C. A. Caldwell, Fairmont, Calif. (1939)		22S	45E	MD	Gold mine. (Tucker, W. B. 38a, p. 479.)
*212	C	Townsend	C. R. Townsend, Keeler, Calif. (1912)	Approx.	16S	38E	MD	Lead-silver mine.
213	D	Trail		36	15S	41E	MD	North-trending vein dips 70° E. (Aubury, L. E. 05, p. 246; 08, p. 304).
214	C	Ubehebe (Copper Bell)	A. Farrington estate, Bishop, Calif. (1938)	1	14S	40E	MD	Lead-silver mine. (Tucker, W. B. 38, p. 17; 38a, p. 479, pl. 3.)
		Ulida: see Vlida						
		Union: see Monte Carlo						
		Utacala group: see Colorado						
*215	D	Valentine group			15S	39E	MD	Granite-limestone contact. (Aubury, L. E. 08, p. 303.)
*216	C	Valley View	L. H. Baxter, Independence Calif. (1934)	Approx.	30N	1E	SB	Lead-silver mine.
*217	C	Vanderberg	D. Vanderberg, Bishop, Calif. (1921)	Approx.	7S	34E	MD	Copper mine?
218	C	Ventura (Silver Reef, Sunset)	C. Baagoe and H.C. Eldridge, Keeler, Calif. (1929); I. Hutton, Lone Pine, Calif. (1941)	23	16S	38E	MD	Lead-silver mine; tetrahedrite in quartz veins. (Tucker, W. B. 26b, p. 503; 38a, pp. 458, 479.)
219	C	Vlida (Ulida)		19	15S	41E	MD	Granite-limestone contact; sorted ore packed to Keeler; two adits, each 150 ft. (Aubury, L. E. 05, p. 246; 08, pp. 304-306.)
*220	C	Wahoo	W. M. Hoover, Lone Pine, Calif. (1939)	Approx.	18S	40E	MD	Gold mine; also lead, silver; veins in quartz monzonite. (Tucker, W. B. 40, p. 25.)

*221	C	Wallace	L. D. Foreman, Salt Lake City, Utah (1944)	Approx.	20S	40E	MD	Lead-silver mine; also gold.
*222	C	Warbaby & Ark	D. Roe, Lone Pine, Calif. (1941)	Approx.	19S	38E	MD	Lead mine.
*223	C	Wardell	Inyo County Mines Development Co., Darwin, Calif. (1905)	Approx.	19S	40E	MD	Copper mine?
224	D	Warren group	W. Lucht and Benjamin Stocton, Big Pine, Calif. (1947)	15	11S	36E	MD	Lead-silver mine; copper mineralization. (Written communication, S. White, 1947.)
225	C	Waucoba	L. B. Bedell, Santa Paula, Calif. (1941)	27	11S	37E	MD	Tungsten-lead-silver mine. (Tucker, W. B. 38a, p. 480, pl. 3.)
*226	C	Weir and Ball	Weir and Ball (1918)					Lead-silver mine.
227	C	Westgard (Chalmers)	Westgard Cons. Mining Co., Big Pine, Calif. (1941)	14	7S	35E	MD	Lead-silver mine. (Tucker, W. B. 38a, p. 480, pl. 3.)
*228	C	Whittier	M. H. Whittier, Los Angeles, Calif. (1920)	Approx.	7S	36E	MD	Lead-silver mine; also gold.
*229	C	Wiggington	J. Wiggington, Keeler, Calif. (1918)	Approx.	16S	38E	MD	Lead-silver mine.
*230	C	Williams	J. Williams, Zabriskie, Calif. (1910)	Approx.	20N	8E	SB	Copper mine?
		Wilshire: see Cardinal						
231	D	Wisconsin		25	19S	39E	MD	Granite-limestone contact; shaft, 150 ft. (Aubury, L. E. 05, p. 245; 08, p. 301.)
		Wonder: see Death Valley						
°232	D	Wonder		13	19S	40E	MD	Gold-copper mine; adit 100 ft. (also others) on 4-ft. quartz vein in metamorphic limestone. (Kelley, V. C. 38, p. 559, pl. 7; Tucker, W. B. 26b, p. 465.)
233	C	Ygnacio (Ignacio)	Ygnacio Mining Co., Keeler, Calif. (1917)	23	16S	38E	MD	Lead-silver mine; also gold. (Tucker, W. B. 38a, pp. 442, 480.)
*234	D	Yoeman	A. Yoeman, Tacopina, Calif. (1913)	Approx.	20N	8E	SB	Copper mine?
*235	C	Zabuski-Gilbert	J. A. Gilbert (1914)					Lead-silver mine; also gold.
		Zinc Hill: see Colorado						

* Not shown on map because of lack of definite location.
° Not shown on map because of crowded condition.

KERN COUNTY

Number	Class by production	Name of deposit	Name of owner or operator	Location Sec.	T.	R.	B. & M.	Remarks and references
*1	C	-----	B. A. Gordon, Isabella, Calif. (1943)	-----	-----	-----	-----	Lead mine.
*2	C	-----	G. B. McElhinnie, Bakersfield, Calif. (1942)	-----	-----	-----	-----	Lead-silver mine; also gold.
3	C	-----	W. J. Gessell, Weldon, Calif. (1940)	21	27S	35E	MD	Tungsten mine; scheelite with ferberite and azurite.
4	C	Amy (Gold State)	Piute Mines, Ltd., Los Angeles, Calif. (1940)	5, 22	29S	34E	MD	Gold mine. (Tucker, W. B. 33, p. 272.)
5	C	Apache	Williams & Hamilton, Los Angeles, Calif. (1940)	32	28S	39E	MD	Gold mine.
*6	C	A. Star	R. Brantley, Mojave, Calif. (1942)	-----	-----	-----	-----	Gold mine.
7	C	Big Blue	Kern Mines, Inc., Kernville, Calif. (1942)	28	25S	33E	MD	Gold mine; also silver, lead. (Prout, J. W. 40; Tucker, W. B. 40, p. 28).
8	C	Big Butte	Butte Lode Mining Co., Los Angeles, Calif. (1942)	36	29S	40E	MD	Gold mine; also silver. (Tucker, W. B. 40, p. 29.)
9	C	Bi-Metallic group	Grote & Spillane, Randsburg, Calif. (1936)	36?	29S	40E	MD	Gold mine; also silver.
*10	C	Black Mountain	C. A. Skaggs, Randsburg, Calif. (1934)	Approx.	29S	39E	MD	Gold mine; also lead, silver. (Tucker, W. B. 29, p. 29.)
11	C	Blue Chief	Blue Chief Mining Corp., San Francisco, Calif. (1935)	15	26S	31E	MD	Lead-silver mine; also gold.
		Blue Eagle: see Cactus Queen						
12	C	Burning Mosco (Burning Moscow)	Piute Mining Co., Cantil, Calif. (1934)	19	28S	35E	MD	Gold mine; also silver. (Tucker, W. B. 33, pl. 6; 38, p. 12.)
13	C	Cactus Queen (Blue Eagle)	Cactus Mines Co., Rosamond, Calif. (1943)	17	10N	13W	SB	Gold-silver mine; also lead. (Tucker, W. B. 40, p. 29.)
		Condor: see Tejon Ranch						
14	D	Copper King	-----	3	27S	33E	MD	Granite-slate contact; high-grade bunches; 230-ft. adit. (Brown, G. C. 16, p. 479.)

		Cully & Hoyes: see Tejon Ranch						
		Cully Hayes: see Tejon Ranch						
		Desert Queen: see Exposed Treasure						
15	C	Exposed Treasure (Desert Queen)	A. J. Bruce, Mojave, Calif. (1935)	32	11N	12W	SB	Gold mine; also silver, lead. (Tucker, W. B. 35, p. 474.)
16	C	Four Star	E. Blickenstaff, Mojave, Calif. (1942)	33	11N	12W	SB	Gold mine; also silver, lead. (Tucker, W. B. 35, p. 474.)
*17	D	Gallow Glass			28S	40E	MD	Wide mineralized zone; one 54-ft. shaft; also 14 other shafts. (Aubury, L. E. 05, p. 241; 08, p. 297.)
18	C	Gold Bug	T. DeMayo et al., Randsburg, Calif. (1942)	35	27S	40E	MD	Gold mine; also silver. (Tucker, W. B. 33, p. 273.)
19	C	Gold Standard	Potter & Moreland, Porterville, Calif. (1939)	12	28S	34E	MD	Gold mine; also silver; veins in slate. (Tucker, W. B. 40b, p. 327, pl. 2.)
		Gold State: see Amy						
20	C	Golden Queen (Silver Queen)	Golden Queen Mining Co., Mojave, Calif. (1942)	6	10N	12W	SB	Gold mine; also silver. (Tucker, W. B. 34, p. 316; 35, pp. 475-479, pl. 6; 40, p. 30.)
21	B	Greenback (Weringer)	J. Weringer, Bakersfield, Calif. (1918)	1, 2, 3, 4, 10	26S	29E	MD	Copper mine; copper minerals in east-trending joint system in granodiorite. Produced 1916-18. (Aubury, L. E. 05, p. 238; 08, pp. 294-296; Brown, G. C. 16, p. 479; Storms, W. H. 13; Tucker, W. B. 21, p. 307; 29, p. 22; Turner, H. W. 02.
*22	D	Hooper			26S	33E	MD	(Aubury, L. E. 05, p. 241; 08, p. 297.)
23	D	Iron Mountain Wonder (Iron Mountain)		10, 15	26S	29E	MD	Iron mine (magnetite); in mica schist; 80-ft. shaft, 60-ft. adit, on two parallel veins in granite, a continuation of Greenback veins. (Brown, G. C. 16, p. 480; Tucker, W. B. 29, p. 56.)
24	C	King Solomon (Windy)	Shipsey Mining Co., South Pasadena, Calif. (1942)	25, 36	29S	40E	MD	Gold mine; also silver. (Tucker, W. B. 40, p. 33.)
25	D	Laymon group	J. M. Laymon, Los Angeles, Calif. (1928)	5, 6	29S	39E	MD	Copper mine (chalcopyrite); also pyrite; quartz vein in schist; 104-ft. shaft; other shafts on 3- to 6-ft. lenses, strike N., dip 45° to 60° E. (Tucker, W. B. 21, p. 308; 29, p. 23.)
		Lida: see Tropico and Lida						
26	C	Maltby		4, 10	26S	29E	MD	Vein in schist; shafts 35, 16 ft.; small lots of ore shipped. (Aubury, L. E. 05, p. 240; 08, p. 296.)
27	D	Manning		7, 18 12, 13	28S 28S	40E 39E	MD MD	2- to 12-in. seams of ore in schist form lenses up to 60 ft. wide. (Aubury, L. E. 05, p. 241; 08, p. 297.)

KERN COUNTY—Continued

Number	Class by production	Name of deposit	Name of owner or operator	Location				Remarks and references
				Sec.	T.	R.	B. & M.	
28	D	Orange Blossom	Mrs. J. S. Bishop, Cantil, Calif. (1928)	6	30S	38E	MD	Copper mine; copper oxides in limestone and quartzite; gossans; adit, 60 ft. on 6- to 20-ft. shear zones. (Tucker, W. B. 29, p. 23.)
*29	C	Rinaldi & Clark	Rinaldi & Clark (1913)					Lead-silver mine; also gold.
30	C	Silver Prince	Golden Queen Mining Co., Mojave, Calif. (1937)	17	10N	13W	SB	Gold mine. (Julihn, C. E. 37, pp. 35-36.)
		Silver Queen: see Golden Queen						(Tucker, W. B. 34, p. 316.)
31	C	Silverado	J. L. Hooper, Hobo Hot Spring, Calif. (1940)	15	27S	33E	MD	Copper mine (chalcopyrite) in granitic dike between schist and limestone; adits 620 ft. and 210 ft. on 3-ft. fissure vein, strike NW, dip 60° SW. Rich ore taken from pockets. (Brown, G. C. 16, p. 480; Tucker, W. B. 40b, p. 323, pl. 2.)
32	D	Spa and Bonanza		3, 4 9, 10	26S	29E	MD	Gossan croppings; four shafts. (Aubury, L. E. 05, p. 241; 08, p. 296.)
33	C	Standard	Standard Hill Mines Co., Rosamond, Calif. (1942)	29, 32	11N	12W	SB	Gold mine; also silver.
*34	C	Teagle	C. J. Teagle, Johannesburg, Calif. (1912)					Copper mine.
*35	C	Tejon Ranch (Cully & Hoyes, Cully Hayes, Condor)			9N	18W	SB	Zinc mine; replacement in limestone along fracture. (Tucker, W. B. 43, p. 65.)
		Tropico: see Tropico and Lida						
36	C	Tropico and Lida (Tropico, Lida)	Burton Bros., Inc., Rosamond, Calif. (1944)	10, 11 14, 15	9N	13W	SB	Gold mine; also silver. (Tucker, W. B. 40, p. 37.)
37	C	Upper Sageland	Upper Sageland Mining Co., Mojave, Calif. (1937)	19	28S	35E	MD	Gold mine; also silver.
38	D	Walsh	W. J. Walsh, Randsburg, Calif. (1928)	35?	28S	38E	MD	Copper mine; several 50- to 100-ft. shafts, 100-ft. adit on parallel disseminated sulphide zones in quartz and schist. (Tucker, W. B. 21, p. 308; 29, p. 24.)
39	D	Walsh and McClaude	Walsh & McClaude, Garlock, Calif. (1928)	7	29S	39E	MD	Copper mine; shallow workings on 3- to 6-ft. chalcopyrite lenses in schist; strike NW, dip 60° E. (Tucker, W. B. 21, p. 308; 29, pp. 23-24.)

		Weringer: see Greenback						
		Windy: see King Solomon						
40	C	Yellow Aster	Yellow Aster Mining & Milling Co., Los Angeles, Calif. (1943)	2 35	30S 29S	40E 40E	MD MD	Gold mine; also silver. (Tucker, W. B. 40, p. 38.)
41	C	Yellow Dog	Yellow Dog Mining Co., Mojave, Calif. (1934)	29, 32	11N	12W	SB	Gold mine. (Tucker, W. B. 35, p. 485.)
42	C	Yellow Treasure	A. De Mayo, Randsburg, Calif. (1943)	5	28S	40E	MD	Gold mine. (Tucker, W. B. 33, p. 339.)
43	C	Zuna	Zuna Copper Mining Co., Randsburg, Calif. (1943)	1	29S	38E	MD	Copper mine?

* Not shown on map because of lack of definite location.

LAKE COUNTY

Number	Class by production	Name of deposit	Name of owner or operator	Location				Remarks and references
				Sec.	T.	R.	B. & M.	
1	D	Christianson Tract		16, 17	13N	7W	MD	112-ft. adit (1878) failed to hit vein on serpentine-limestone contact; float found. (Aubury, L. E. 05, p. 139; 08, p. 164.)
2	C	Copper Prince	H. C. Betts, Middletown, Calif. (1915)	19	11N	7W	MD	Copper mine; also silver, gold; produced in 1915; 100-ft., and two other adits; 50-ft. crosscut on 6- to 8-ft. vein of azurite, malachite, and sulphide in limestone. (Aubury, L. E. 05, p. 138; 08, pp. 163-164; Bradley, W. W. 16, p. 206; Averill, C. V. 29b, p. 341.)
3	D	Poe		27	15N	10W	MD	(Bradley, W. W. 16, p. 206.)
4	D	Reynolds	E. Reynolds, Middletown, Calif. (1928)	24	11N	8W	MD	Copper mine, near Copper Prince. (Averill, C. V. 29b, pp. 341-342.)

LASSEN COUNTY

Number	Class by production	Name of deposit	Name of owner or operator	Location: Sec.	Location: T.	Location: R.	Location: B. & M.	Remarks and references
*1	C	Alexander	A. Knock, Susanville, Calif. (1908)	Approx.	29N	11E	MD	Gold mine; also silver.
		Badger: see Honey Lake						
*2	C	California & Utah	California & Utah Cons. Gold Mining Co., Doyle, Calif. (1913)					Silver mine.
3	D	Cooper Hill		28	28N	10E	MD	Low-grade, disseminated copper mineralization in zone 500 ft. wide, 3,000 ft. long in diorite. Thought to be continuation of Engels. (Laizure, C. McK 21, pp. 507-508.)
4	D	Corona	Corona Mining Co., Westwood, Calif. (1928)	5	26N	15E	MD	Copper mine; active 1928-29; 50-ft. shaft; 550-ft. adit; failed to hit vein of disseminated chalcopyrite in diorite. (Averill, C. V. 29, p. 5; 36, p. 424; Tucker, W. B. 23c, p. 135.)
5	C	Honey Lake (Badger)	Honey Lake Mining Co., Doyle, Calif. (1935)	32	27N	15E	MD	Gold mine; also silver, lead. (Averill, C. V. 36, p. 435.)
6	C	Juniper	H. C. Jack, Bieber, Calif. (1939)	36	37N	9E	MD	Gold mine; also silver. (Averill, C. V. 36, p. 436; Preston, E. B. 90a, p. 212.)
7	C?	Mountain Meadows	C. F. Huling et al., Woodbury Center, Iowa (1944)	29, 32	28N	10E	MD	Copper mine; 100-ft. shaft, 900-ft. adit, on veins in meta-andesite conglomerate. Small production, 1913-14. (Averill, C. V. 36, p. 424; Tucker, W. B. 19, pp. 228-229.)

* Not shown on map because of lack of definite location.

LOS ANGELES COUNTY

Number	Class by production	Name of deposit	Name of owner or operator	Location: Sec.	Location: T.	Location: R.	Location: B. & M.	Remarks and references
*1	C		T. R. Cotterell, Gorman, Calif. (1942)	Approx.	8N	16W	SB	Gold mine? Also lead, silver.
2	C	Big Horn	Big Horn Mining Co., Buffalo, N.Y. (1935)	7, 8	3N	8W	SB	Gold mine; also silver, lead. (Sampson, R. J. 37, p. 178.)
3	C	Big Susanna	Rogers & Gentry, Fairmont, Calif. (1942)	27	8N	16W	SB	Gold mine; also silver.
		Chance: see Denver						
4	D	Clearwater group	Arthur R. Plumb, Los Angeles, Calif. (1937)	21	6N	15W	SB	Copper mine; copper carbonates in hornblende schist; 100-ft. adit. (Sampson, R. J. 37, pp. 175-176.)
		Conover: see Emma group						
5	D	Denver group (Denver, Chance, Fenner, Indicator, Red Ledge)	Denver Mining and Milling Co., Los Angeles, Calif. (1936)	10, 11	3N	14W	SB	Copper-lead-zinc mine; also cobalt and antimony; complex mineralization; a number of shafts and adits on parallel quartz veins in schist. (Tucker, W. B. 21, p. 318; 27, p. 289; Sampson, R. J. 37, p. 176.)
6	C	Emma group (Conover, Parker Mountain)	Bournite Mining Co., Los Angeles, Calif. (1943)	15	4N	13W	SB	Copper-silver mine; also gold; 4- to 6-ft. quartz veins with copper, silver, and gold, in granite; adits 500 and 100 ft.; shafts, two 75 ft., two 40 ft., one 35 ft.; leaching operation carried on in 1926 on 1-2% Cu ore. (Merrill, F. J. H. 19, p. 472; Preston, E. B. 90, pp. 194-195; Sampson, R. J. 37, p. 176; Tucker, W. B. 27, pp. 290-291.)
*7	C	Fay Securities	Fay Securities Co., Los Angeles, Calif. (1936)					Gold mine; also silver.
		Fenner: see Denver						
8	C	Free Cuba		1	4N	13W	SB	Shaft, 200 ft. on 20-ft. quartz vein in granite; worked in early days. (Aubury, L. E. 05, p. 261; 08, p. 346; Merrill, F. J. H. 19, p. 471.)
9	C	Governor (New York)	Governor Mines Co., Los Angeles, Calif. (1942)	21, 23 24	5N	13W	SB	Gold mine; also silver. (Tucker, W. B. 40, p. 43.)
*10	C	Howe	C. W. Howe, Pasadena, Calif. (1936)					Gold mine; also silver.

LOS ANGELES COUNTY—Continued

Number	Class by products	Name of deposit	Name of owner or operator	Location				Remarks and references
				Sec.	T.	R.	B. & M.	
		Indicator: see Denver						
11	D	King of the West	R. E. Nickel, Acton, Calif. (1936)	1	4N	13W	SB	Copper mine (malachite, bornite); also gold, silver; 4-ft. quartz vein in granite; shaft, 150 ft. (Sampson, R. J. 37, p. 176; Tucker, W. B. 27, p. 290.)
*12	C	Los Padre	Los Padre Mining Co., Los Angeles, Calif. (1938)					Gold mine; also silver.
13	D	Mooney & Williams		12	4N	13W	SB	Similar to Free Cuba. (Aubury, L. E. 05, p. 261; 08, p. 346.)
		New York: see Governor						
14	D	Palm Development Co.		30	5N	10W	SB	Copper mine; copper minerals in 180-ft. porphyry dike. (Aubury, L. E. 05, p. 261; 08, p. 346; Sampson, R. J. 37, p. 175.)
		Parker Mountain: see Emma						
		Red Ledge: see Denver						
15	C	Santa Catalina (Santa Catalina Island)	G. Murphy (1931)	23?	8S	16W	SB	Copper-lead-silver-zinc prospect; also ocher. (Sampson, R. J. 37, p. 174; Tucker, W. B. 27, p. 291; Preston, E. B. 90b, pp. 279-280.)
16	D?	Silver Mountain	E. Morgan, Los Angeles, Calif. (1936)	31?	2N	9W	SB	Copper mine. (Sampson, R. J. 37, p. 176.)
17	C	Valvue	Rogers & Gentry, Fairmont, Calif. (1942)	27	8N	16W	SB	Gold mine; also silver.
		Winter Creek: see Winter group						
18	D	Winter group (Winter Creek)	O. L. Roberts, Roberts Camp, Calif. (1937)	3	1N	11W	SB	Copper mine (chalcopyrite, bornite); also silver, molybdenite; two parallel veins, 1 to 3 ft. wide, in granite and diorite; adits 170 ft., 50 ft., 40 ft., and 40 ft.; drifts, 100 ft., 80 ft. (Sampson, R. J. 37, pp. 176-177.)

* Not shown on map because of lack of definite location.

MADERA COUNTY

Number	Class by production	Name of deposit	Name of owner or operator	Location Sec.	Location T.	Location R.	Location B. & M.	Remarks and references
*1	C	Adobe Ranch			10S	19E	MD	(Aubury, L. E. 05, p. 222; 08, p. 276.)
*2	C	American Exploration Co.	W. P. Anderson, Kennett, Calif. (1908)					Gold mine; also silver.
*3	C	Apex	G. W. Bever, Chowchilla, Calif. (1919)	Approx.	9S	17E	MD	Gold mine; also silver.
4	C	Bach	R. C. Bach, Stockton, Calif. (1929)	8?	9S	18E	MD	Copper mine; also silver; small bodies of high-grade ore, worked in 1926? Shaft, 70 ft.; drift, 100 ft. (Laizure, C. McK 28a, p. 322.)
*5	C	Bagnelli	R. L. Bagnelli, Jesbel, Calif. (1918)	Approx.	9S	18E	MD	Copper mine; also gold, silver.
*6	C	Barnett	J. R. Barnett, Raymond, Calif. (1911)	Approx.	8S	19E	MD	Copper mine; also silver.
		Belle: see Jesse Bell						
7	D	Big Chief		23	10S	21E	MD	Three veins 2-8 ft. wide; active in 1902. (Aubury, L. E. 05, p. 222; 08, p. 276.)
8	D	Biladeau (Bradford and Smith)	L. M. Bradford, Box 207, Madera, Calif. (1943)	9	5S	22E	MD	Zinc-silver-lead-copper mine; contact zone up to 50 ft. wide. (Laizure, C. McK 28a, p. 335.)
		Bliss group: see Galena King						
9	D	Blue Bird claim	S. M. Mingus et al., Coalinga, Calif. (1925)	36?	3S	25E	MD	Copper mine. (Bradley, W. W. 26, pp. 546, 556.)
		Bradford and Smith: see Biladeau						
		Bruce: see Galena King						
10	B	Buchanan	U.S. Smelting, Refining, & Mining Co., Newhouse Bldg., Salt Lake City, Utah (1943)	34	8S	18E	MD	Copper mine; also silver, gold; pyrrhotite ore in andalusite schist; produced 1910-20. (Aubury, L. E. 05, p. 218; 08, pp. 270-272; Browne, J. R. 67, pp. 143, 163, 167; 68, pp. 213-214; Lang, H. 07, p. 1007; McLaughlin, R. P. 16, p. 538.)
*11	B	Bussolini	R. Bussolini, Raymond, Calif. (1917)	Approx.	8S	19E	MD	Copper mine; also gold, silver.
		California Copper Co.: see Daulton						

MADERA COUNTY—Continued

Number	Class by production	Name of deposit	Name of owner or operator	Location				Remarks and references
				Sec.	T.	R.	B. & M.	
*12	C	California-Nevada	Globe Arizona Smelter, Daulton, Calif. (1907)	Approx.	9S	18E	MD	Copper mine; also silver.
13	D	Cochran	I. N. Cochran et al. (1925)	32?	3S	26E	MD	Copper mine. (Bradley, W. W. 26, p. 556.)
14	C	Copper Queen	O. R. Sydney, Raymond, Calif. (1917)	15	9S	18E	MD	Copper mine; also silver. (Aubury, L. E. 08, p. 272.)
15	A?	Daulton (California Copper Co., Ne Plus Ultra)	L.M. Bradford, Box 207, Madera, Calif.; lessee, A. J. Oyster, San Francisco, Calif. (1943)	35	9S	18E	MD	Copper mine; also zinc; pyrrhotite ore in andalusite schist. (Boalich, E. S. 21, p. 83; Laizure, C. McK 28a, p. 322; Lang, H. 07, p. 1007; McLaughlin, R. P. 16, p. 538.)
*16	C	Erskine	A. H. Erskine, Raymond, Calif. (1918)	Approx.	8S	19E	MD	Copper mine; also silver.
*17	B	Felts	E. R. Felts, Raymond, Calif. (1913)	Approx.	8S	19E	MD	Copper mine; also silver, gold.
*18	C	Florence	C. H. Beck, O'Neals, Calif. (1919)	Approx.	9S	21E	MD	Gold mine; also silver.
*19	D	Francis			5S	22E	MD	Zinc-copper prospect. (Laizure, C. McK 28a, p. 336.)
20	C	Galena King (Bliss group, Bruce group)	L. R. and R. B. Harris, North Fork, Calif. (1930)	9, 10	3S	25E	MD	Lead-silver mine; also gold. (Erwin, H. D. 34, p. 77; Laizure, C. McK 28a, p. 340.)
*21	C	Golden Heel & Enterprise	M. Lovely, Grub Gulch, Calif. (1915)	Approx.	7S	20E	MD	Copper mine.
*22	C	Halliday	F. G. Halliday, Raymond, Calif. (1916)	Approx.	8S	19E	MD	Copper mine; also silver.
23	C	Jesse Belle (Bell); Jessie Bell (Belle); Jesbel	Daulton & Buchanan estates (Clay Daulton, Raymond, Calif.); lessee, W. M. Hoff, 243 S. Olive St., Los Angeles, Calif. (1943)	13 18, 19	9S 9S	18E 19E	MD MD	Copper mine; lenses of pyrite, pyrrhotite, and chalcopyrite in biotite schist; little or no zinc; cobaltite (?). (Forstner, W. 08, p. 747; Laizure, C. McK 28a, p. 323; Neale, W. G. 27, p. 499.)
		Joe Wagner: see Vignola, Minaret						
24	D	Kennedy (King Creek group, Superior)	J. Kennedy (1925)	31?	3S	26E	MD	Copper mine. (Bradley, W. W. 26, pp. 546, 557; Erwin, H. D. 34, p. 77.)
		King Creek group: see Kennedy						
25	D	Krohn and Ward	Krohn family, Coarse Gold, Calif. (1943)	23, 26	10S	19E	MD	(Aubury, L. E. 05, p. 222; 08, p. 276.)

26	C	Minaret (Johnson group, Johnston)	Minaret Cons. Mining Co., c/o C. C. Randall, A. G. Bartlett Bldg., Los Angeles, Calif. (1931)	19?	3S	26E	MD	Lead-silver-copper mine; also zinc; has been diamond-drilled. (Bradley, W. W. 26, pp. 546, 551; Laizure, C. McK 28a, p. 340; Erwin, H. D. 34, p. 74; Rand, L. H. 31, p. 611.)
*27	C	Mount Raymond			5S	22E	MD	Copper mine.
28	C	Nelson		25, 26	9S	18E	MD	Formerly part of Daulton group.
		Ne Plus Ultra: see Daulton						
29	D	Nidever	D. C. Nidever (1927)	12?	3S	25E	MD	Zinc-copper-lead-silver mine. (Bradley, W. W. 26, pp. 546-547; Erwin, H. D. 34, p. 73; Laizure, C. McK 28a, p. 340.)
*30	C	Old Daulton	J. A. Ross, Fresno, Calif. (1924)	Approx.	9S	18E	MD	Copper mine.
31	D	Old Reed		16	10S	21E	MD	(Aubury, L. E. 05, p. 222.)
*32	B	Pearce & Pearce	J. B. Pearce, Raymond, Calif. (1915)	Approx.	8S	19E	MD	Copper mine; also silver, gold.
*33	B	Probasco	J. B. Pearce, Raymond, Calif. (1912)	Approx.	8S	19E	MD	Copper mine.
34	C	Questo	Buchanan estate, c/o H. J. Buchanau, Madera, Calif. (1943)	2	10S	18E	MD	South extension of Daulton; produced in 1902. (Aubury, L. E. 05, p. 220; 08, p. 274.)
35	D?	Saddle claim	S. M. Mingus et al., Coalinga, Calif. (1925)	32?	3S	26E	MD	Copper mine. (Bradley, W. W. 26, pp. 546, 556.)
*36	C	San Jose	Erskin, Harlan, & Leonard, Raymond, Calif. (1916)	Approx.	8S	19E	MD	Copper mine; also silver.
*37	D	Scandia			5S	22E	MD	Zinc-copper prospect. (Laizure, C. McK 28a, p. 336.)
38	D	Shadow claim	S. M. Mingus et al., Coalinga, Calif. (1925)	8?	3S	26E	MD	Copper mine. (Bradley, W. W.26, pp. 546, 556.)
39	D	Silver Reef claim	S. M. Mingus et al., Coalinga, Calif. (1925)	8?	3S	26E	MD	Copper-silver mine; vein on granite-slate contact. (Bradley, W. W. 26, pp. 546, 556.)
40	C	S.P. group	J. Broad, Oakland, Calif. (1928)	10?	5S	22E	MD	Lead-zinc prospect. (Laizure, C. McK 28a, p. 335.)
41	C	Star	Mrs. E. M. Wittlesey, San Francisco, Calif. (1928)	10	5S	22E	MD	Lead-zinc mine. (Laizure, C. McK 28a, p. 334; McLaughlin, R. P. 16, p. 558.)
42	D	Sullenger (Tom Agnew)	J. R. Sullenger, Keeler, Calif. (1925)	9?	3S	26E	MD	Silver mine; also lead, copper, zinc; sulphides, carbonates, chlorides, in quartz stringers in schist and slate. (Bradley, W. W. 26, pp. 546; 551; Erwin, H. D. 34, p. 74.)
		Superior: see Kennedy						

MADERA COUNTY—Continued

Number	Class by production	Name of deposit	Name of owner or operator	Location: Sec.	T.	R.	B. & M.	Remarks and references
		Tom Agnew: see Sullenger						
*43	C	Victory	P. Rosati, Raymond, Calif. (1944)	Approx.	8S	19E	MD	Copper.
44	C	Vignola (Joe Wagner)	Ceasar Vignola, Raymond, Calif. (1943)	2 35	9S 8S	18E 18E	MD MD	Copper mine; also silver. (Aubury, L. E. 08, p. 272.)
45	D	Vulcan (Yosemite)	Vulcan Copper Co., New York, N.Y. (1928)	1, 12, 13 6, 7	5S 5S	22E 23E	MD MD	Magnetite, pyrite, with copper stain. (Laizure, C. McK 28a, p. 336; McLaughlin, R. P. 16, p. 554.)
*46	D	Ward	------	------	7S	19E	MD	(Aubury, L. E. 08, p. 276.)
		Yosemite: see Vulcan						
*47	C	Zerzi	Rosat & Le Bery, Raymond, Calif. (1920)	Approx.	8S	19E	MD	Copper mine.

* Not shown on map because of lack of definite location.

MARIN COUNTY

Number	Class by production	Name of deposit	Name of owner or operator	Location: Sec.	T.	R.	B. & M.	Remarks and references
1	C	Bolinas mine (Cheteo)	Chetco Mining Co., San Francisco, Calif. (1918)	1	1N	8W	MD	Copper mine; also silver, gold; 180-ft. shaft; more than 2,500 ft. of drifts from 180-ft. and 100-ft. levels, on nine parallel veins in serpentine; some ore shipped in early days; 22,500 lbs. of copper recorded from Marin County in 1918 was probably from Bolinas mine. (Aubury, L. E. 05, p. 143; 08, p. 168; Bradley, W. W. 16, p. 248; Crawford, J. J. 96, p. 59; Laizure, C. McK 26a, p. 320; Watts, W. L. 93b, p. 253.)
		Cheteo: see Bolinas						

MARIPOSA COUNTY

Number	Class by production	Name of deposit	Name of owner or operator	Location: Sec.	T.	R.	B. & M.	Remarks and references
*1	C	----------	C. Gliszinski, Mariposa, Calif. (1912)	Approx.	4S	17E	MD	Gold mine.
2	C	A. C. Smith	----------	9	7S	17E	MD	80-ft. shaft; intermittent production, 1883-1908. (Aubury, L. E. 08, p. 262.)
3	C	Akoz (B. A. B., Radium)	M. Erickson, La Grange, Calif. (1944)	9, 10	4S	15E	MD	Zinc mine; also copper, silver, gold; triboluminescent sphalerite, with barite and tetrahedrite; on the assumption that it contained radium, this material, at one time, sold under name "Akoz", for medicinal purposes. (Eakle, A. S. 04, p. 1000; Laizure, C. McK 28, p. 143; Lang, H. 07, p. 963.)
4	C	American Eagle	Valberde Bros., Hornitos, Calif. (1943)	30	4S	16E	MD	Copper (malachite, azurite) with zinc (sphalerite), in sericite schist: about 1500 ft. of workings; sorted over $90 in Au, Ag, Cu; adjoins south end of Blue Moon. (Laizure, C. McK 28, p. 124.)
*5	C	Anderson	H. F. Anderson, Hornitos, Calif. (1918)	Approx.	5S	16E	MD	Copper mine.
		B. A. B.: see Akoz						
6	C	Bandarita	N. M. Leoni, Lemoore, Calif. (1944)	12	3S	17E	MD	Gold mine; also silver. (Julihn, C. E. 40, pp. 141-142; Laizure, C. McK 35, map op. p. 28.)
7	C	Barrett (Barretta, Berette)	Harry Barrett, Coulterville, Calif. (1943)	29 30, 32	3S	16E	MD	Gold; also copper, zinc; shaft 200 ft.; $90,000 reported recovered from one gold pocket. (Aubury, L. E. 05, p. 215; 08, p. 267; Castello, W. O. 21, p. 102; Lang, H. 07, p. 966.)
		Berette: see Barrett						
8	C	Black Oak	Golden Opportunity, Inc., Coulterville, Calif. (1936)	8	5S	20E	MD	Gold mine; also silver. (Laizure, C. McK 28, p. 130.)
		Blue Cloud: see Blue Moon						
9	B	Blue Moon (Blue Cloud, Red Cloud)	Hecla Mining Co., Wallace, Idaho (1944); Red Cloud Mines, Inc., Hornitos, Calif. (1943)	19	4S	16E	MD	Zinc mine; also lead, silver, gold; sphalerite with barite, tetrahedrite, and pyrite, in sericite schist; copper produced 1935, 1942, 1944, 1945.
10	C	Bondurant	Bondurant Mining & Milling Co., San Francisco, Calif. (1940)	24, 25 36	2S	17E	MD	Gold mine; also silver, lead. (Julihn, C. E. 40, pp. 138-139; Laizure, C. McK 35, map op. p. 28.)

MARIPOSA COUNTY—Continued

Number	Class by production	Name of deposit	Name of owner or operator	Location: Sec.	T.	R.	B. & M.	Remarks and references
11	D	Bruschi	F. J. Bruschi, Coulterville, Calif. (1927)	24	3S	15E	MD	Copper mine. (Aubury, L. E. 05, p. 215; Laizure, C. McK 28, p. 139.)
12	C	Canyon Wren	T. J. Patrick, Mariposa, Calif. (1937)	21	6S	18E	MD	Gold mine; also silver.
		Castagnetto: see Castignetto						
13	D	Castignetto (Castagnetto)		26	2S	16E	MD	Gold mine; strong gossan; 30-ft. shaft. (Aubury, L. E. 05, p. 215; Laizure, C. McK 28, p. 130.)
14	C?	Cavagnero (Orange Blossom)	Grace N. Cavagnero, Hornitos, Calif. (1943)	9	4S	16E	MD	Copper mine; also gold. (Laizure, C. McK 28, p. 77.)
15	C	Cavan (San Jose group)	S. L. Thrift, Stockton, Calif. (1928)	5	8S	18E	MD	Copper mine; chalcopyrite in andalusite schist. (Aubury, L. E. 05, pp. 206-208; 08, pp. 257-258; Castello, W. O. 21, p. 103; Julihn, C. E. 40, p. 167; Laizure, C. McK 28, p. 77; Lowell, F. L. 16c, p. 573; Reid, J. A. 08, p. 49.)
16	C	Champion	Car Da Mining Co., Coulterville, Calif. (1938)	28	2S	16E	MD	Gold mine. (Julihn, C. E. 40, pp. 110-111; Logan, C. A. 35, p. 183; Laizure, C. McK 28, p. 83; Preston, E. B. 90c, pp. 302-304.)
17	C	Copper Hill		14	6S	16E	MD	Patented claim; 60-ft. shaft. (Aubury, L. E. 03, p. 15.)
		Copper King: see White Rock						
°18	C	Copper Mountain	Lewis Ryna Copper Mining Co., (1904)	33, 34	7S	18E	MD	Copper mine; also silver, gold.
19	D?	Copper Queen		3	8S	18E	MD	Copper mine. (Laizure, C. McK 28, p. 125.)
20	C	Copper Queen	O. R. Sidney, Ben Hur, Calif. (1912)	19	5S	19E	MD	Copper mine; also silver, gold; native copper; shaft 40 ft. (Aubury, L. E. 05, p. 216; 08, p. 268; Pabst, A. 38, p. 29.)
21	C	Cornett		19	6S	17E	MD	Average copper in the 160 sacks shipped, 20%. (Aubury, L. E. 05, p. 212; 08, p. 264.)
22	C	Cotton Creek	Cotton Creek Mining Co., Hornitos, Calif. (1939)	22	4S	16E	MD	Gold mine; also silver, lead. (Julihn, C. E. 40, p. 120.)
*23	C	Domingues	A. W. Givens, Merced, Calif. (1942)	Approx.	4S	16E	MD	Gold mine; also silver.

24	C	Enterprise Extension	W. C. Johnson, Hornitos, Calif. (1940)	2	5S	16E	MD	Gold mine; also silver. (Laizure, C. McK 28, p. 125.)
*25	C	Farrari (Maschio)	Frank Maschio, Hornitos, Calif. (1943)		3S	16E	MD	Gold production reported ($5000); shaft, 50 ft. (Aubury, L. E. 05, p. 215; 08, p. 267.)
26	C	Feliciana	R. Wilson, Midpines, Calif. (1943)	13	4S	18E	MD	Gold mine; also silver, lead. (Laizure, C. McK 35, map op. p. 28.)
27	C	Goodview	Cavan Mining Co., Stockton, Calif. (1902)	5, 8, 9 32	8S 7S	18E 18E	MD MD	Gold mine; also silver. (Laizure, C. McK 28, p. 125.)
28	C	Granite King	E. E. McElliott, Mariposa, Calif. (1941)	10	6S	18E	MD	Gold mine; also silver, lead. (Julihn, C. E. 40, p. 134.)
29	B	Great Northern		2, 3 10, 11	7S	17E	MD	Copper mine; shafts 110, 70, 25 ft.; ore 1 to 8 ft. wide; production prior to 1907, mostly oxidized ore. (Aubury, L. E. 05, p. 209; 03, p. 15; Laizure, C. McK 28, p. 77; Lang, H. 07, p. 1010.)
		Green: see Johnnie Green						
30	B	Green Mountain	A. B. Smith, 334 Mason St., San Francisco, Calif. (1943)	3, 4 33, 34	8S 7S	18E 18E	MD MD	Copper mine; pyrrhotite and chalcopyrite; in sericite schist; products used in paint, insect spray, fertilizer, and face powder. (Aubury, L. E. 05, pp. 204-206; 08, pp. 253-254; Browne, J. R. 68, p. 214; Castello, W. O. 21, p. 103; Forstner, W. 08, p. 747; Julihn, C. E. 40, pp. 165-166; Laizure, C. McK 28, pp. 77-78; Lang, H. 07, pp. 964, 1006, 1010; Lowell, F. L. 16c, p. 572.)
31	C	Hasloe	W. McLean et al., Coulterville, Calif. (1942)	1, 2	3S	17E	MD	Gold mine; also silver. (Julihn, C. E. 40, pp. 139-140; Laizure, C. McK 28, p. 126.)
*32	C	Hauser	W. H. Hauser, Oakland, Calif. (1941)	Approx.	4S	16E	MD	Gold mine; also silver.
33	C	Heiser		19	5S	19E	MD	Native copper; shaft 30 ft. (Aubury, L. E. 15, p. 216; 08, p. 268.)
34	C?	Hotaling		12?	6S	16E	MD	Copper mine. (Lang, H. 07, p. 910.)
35	D	Indian Peak group		19, 20	6S	20E	MD	Granite-limestone contact; about 500 ft. of workings. (Lowell, F. L. 16c, p. 574.)
36	C	Jenny Lind (Washington)	Lind Mining Co., Hornitos, Calif. (1942)	4, 5	5S	16E	MD	Gold mine; also silver, lead. (Laizure, C. McK 28, p. 128.)
37	C	John Dias		12	6S	16E	MD	Shaft 24 ft.; vein 3 ft. (Aubury, L. E. 05, p. 213; 08, p. 265.)
38	C	Johnnie Green (Green, Johnny Green)	Felts Bros., Raymond, Calif. (1917)	31	7S	18E	MD	Silver; small bodies of rich oxidized ore. (Lang, H. 07, p. 964.)
		Josephine: see Pine Tree and Josephine						

MARIPOSA COUNTY—Continued

Number	Class by production	Name of deposit	Name of owner or operator	Location				Remarks and references
				Sec.	T.	R.	B. & M.	
39	C	Jumper and Bear	C. H. Burt, Bear Valley, Calif. (1940)	25	4S	16E	MD	Gold mine; also silver. (Laizure, C. McK 28, p. 133.)
*40	C	Keyshaft	Keyshaft Mine, Hornitos, Calif. (1936)					Copper mine.
*41	C	King			7S?	18E	MD	Small bodies of rich ore. (Lang, H. 07, p. 964.)
42	C	Klondike claim	R. S. Calhoun, Lewis, Calif. (1913)	16	7S	18E	MD	Copper mine.
		La Victoire: see La Victoria						
43	B	La Victoria (Victoria, La Victoire, Victory)	Grace N. Cavagnero, Hornitos, Calif., and heirs of Duther estate; lessee R. B. Lamb, Mariposa, Calif. (1943)	4, 9 10	4S	16E	MD	Copper-zinc mine; pockets and kidneys in pyroclastics. (Aubury, L. E. 05, pp. 213-215; 08, pp. 265-267; Browne, J. R. 67, pp. 151-152; 68, p. 213; Castello, W. O. 21, p. 103; Julihn, C. E. 40, pp. 167-168; Laizure, C. McK 28, p. 79; Lang, H. 07, p. 1010.)
*44	C	Legioneer	Legioneer Gold Mining Co., Raymond, Calif. (1903)	Approx.	8S	18E	MD	Copper mine
45	C	Lonesome Pine	K. Love, Mt. Bullion, Calif. (1937)	18	5S	18E	MD	Gold mine; also silver.
46	B	Lone Tree	J. W. Westfall, Merced, Calif. (1943)	4 33	8S 7S	18E 18E	MD MD	Copper mine; just northwest of Green Mountain mine; small body high-grade secondary sulphide ore, also oxidized ore; 200 ft. shaft, drifts. (Aubury, L. E. 03, p. 15; 05, p. 206; 08, p. 257; Julihn, C. E. 40, p. 166; Laizure, C. McK 28, p. 77; Lang, H. 07, p. 964.)
47	C	Malvina group (Melvina)	Boston California Mining Co., Sonora, Calif. (1942)	4	3S	16E	MD	Gold mine; also silver, lead. (Julihn, C. E. 40, pp. 104-107; Laizure, C. McK 35, map op. p. 28, p. 36.)
48	C	Mammoth group	Leonard & Sidney, Copper via Raymond, Calif. (1907)	8, 9	8S	18E	MD	Gold mine; three veins; shafts 80, 50, 25 20, ft.; production about 1905, 1907.
49	C	Mariposa Grant (Mariposa)	A. Erickson, Oakdale, Calif. (1929)	23	5S	18E	MD	Gold mine; also silver. (Julihn, C. E. 40, pp. 154-157; Laizure, C. McK 28, p. 99; 35, map op. p. 28.)
		Maschio: see Farrari						
		Melvina: see Malvina						
50	C	Miners Hope (Spread Eagle)	Whitlock Mines Corp., Boston, Mass. (1939)	29, 32	4S	18E	MD	Gold mine, also silver. (Julihn, C. E. 40, pp. 148-150; Laizure, C. McK 35, map op. p. 28.)

51	C	Mount Gaines	Mt. Gaines Mining Co., Hornitos, Calif. (1944)	35, 36	4S	16E	MD	Gold mine; also silver, lead. (Julihn, C. E. 40, pp. 121-125; Laizure, C. McK 35, map op. p. 28; p. 39.)
		Orange Blossom: see Cavagnero						
52	C	Ora Rica (Oro Rico)	J. C. Wilson, Coulterville, Calif. (1912)	19 20, 29	2S	16E	MD	Gold mine; also silver, lead. (Laizure, C. McK 28, p. 109; 35, p. 40.)
53	C	Original	Original Mining & Milling Co., Merced, Calif. (1937)	16, 21 22, 27	3S	19E	MD	Gold mine; also silver, lead. (Laizure, C. McK 35, map op. p. 28; Julihn, C. E. 40, pp. 143-145.)
		Oro Rico: see Ora Rica						
54	C	Pine Tree & Josephine	Pacific Mining Co., San Francisco, Calif. (1944)	8, 9	4S	17E	MD	Gold mine; also silver, lead. (Julihn, C. E. 40, pp. 107-110; Laizure, C. McK 35, map op. p. 28.)
55	B	Pocohontas	c/o Lee M. Olds, 57 Post St., San Francisco, Calif. (1943)	1, 12 14	7S	17E	MD	Copper mine; also gold, silver; sulphides in garnet and andalusite schist. Reid (08) says vein cut off on south by granite (probably part of Sierra Nevada batholith); within granite are dragged masses of ore, some wholly surrounded by granite; therefore copper is pre-granite. (Aubury, L. E. 05, pp. 209-210; 08, pp. 260-262; Castello, W. O. 21, p. 103; Forstner, W. 08, p. 747; Julihn, C. E. 40, p. 166; Laizure, C. McK 28, p. 77; Lang, H. 07, p. 1010; Lowell, F. L. 16, p. 573.)
*56	C	Porcupine	Red Cloud Mines, Inc., Hornitos, Calif. (1940)	Approx.	4S	16E	MD	Copper mine; also silver, gold.
		Radium: see Akoz						Luminescent zinc ore; also lead, antimony. (Eakle, A. S. 04, p. 1000; Lang, H. 07, pp. 963-964.)
57	C	Red Banks (Red Bank)	F. W. Draper, Bagby, Calif. (1940)	36	3S	16E	MD	Gold mine; also silver. (Laizure, C. McK 35, p. 43.)
		Red Cloud: see Blue Moon						
58	D	Rihn Ranch		13	3S	15E	MD	Shafts 60 and 40 ft. deep. (Aubury, L. E. 05, p. 215; 08, p. 268.)
59	C	Ruth Pierce	Tennessee Mining Co., Hornitos, Calif. (1943)	13	5S	16E	MD	Gold mine; also silver, lead. (Julihn, C. E. 40, pp. 126-127; Laizure, C. McK 35, p. 43.)
*60	D?	Salome		Approx.	3S	15E	MD	Copper mine; named on map in Lang, H. 07, p. 910.
		San Jose: see Cavan						
*61	C	Savage & Lundy	Savage & Lundy, Usona, Calif. (1935)	Approx.	3S	19E	MD	Gold mine.
		Spread Eagle: see Miners Hope						
62	C	Texas Hill	G. D. Frank, San Jose, Calif. (1943)	7, 8	3S	18E	MD	Gold mine; also silver, lead. (Laizure, C. McK 35, p. 45.)
63	C	Toad		31	7S	18E	MD	Copper mine; small bodies of rich ore. (Lang, H. 07, p. 964.)

MARIPOSA COUNTY—Continued

Number	Class by production	Name of deposit	Name of owner or operator	Location				Remarks and references
				Sec.	T.	R.	B. & M.	
*64	C	Treasure	J. W. McGinn Co., Hornitos, Calif. (1912)	Approx.	5S	16E	MD	Gold mine; also silver.
		Victoria: see La Victoria Victory: see La Victoria						
65	C	Virginia	F. L. Morris, San Francisco, Calif. (1936)	13, 14	3S	16E	MD	Gold mine; also silver. (Laizure, C. McK 28, p. 128; 35, map op. p. 28.)
66	D	Ward		34	6S	19E	MD	Copper mine; native copper in ore. (Aubury, L. E. 05, p. 216; 08, p. 268.)
		Washington: see Jenny Lind White Knob: see White Rock						
67	B?	White Rock (Copper King, White Knob)	James Helm, Le Grand, Calif. (1943)	14	7S	17E	MD	Copper mine; small lots 30% ore shipped in 1902; patented. (Aubury, L. E. 05, p. 211; 03, p. 15; 08, pp. 262-264; Julihn, C. E. 40, pp. 166-167; Laizure, C. McK 28, p. 211; Reid, J. A. 08, p. 49.)
*68	C	Wilcox	C. R. Wilcox, Lewis, Calif. (1913)	Approx.	7S	17E	MD	Gold mine; also silver.
*69	D?	Woods		Approx.	3S	16E	MD	Copper mine. (Lang, H. 07, p. 964; map, p. 910.)
*70	D	Yosemite			4S	17E	MD	Adit 300 ft. (Aubury, L. E. 08, p. 264.)

* Not shown on map because of lack of definite location.
° Not shown on map because of crowded condition.

MENDOCINO COUNTY

Number	Class by production	Name of deposit	Name of owner or operator	Location: Sec.	T.	R.	B. & M.	Remarks and references
1	D	Deep Hole (Eden Valley)		13	20N	12W	MD	Quartz and chalcopyrite; 40-ft. shaft cutting three veins 4 in. to 1 ft. (Lowell, F. L. 16b, p. 418.)
		Eden Valley: see Deep Hole						
2	D	McGimpsey		13? 17, 18	13N	12W	MD	Copper stains in serpentine. (Lowell, F. L. 16b, p. 413.)
3	D	Native Copper		23	13N?	12W?	MD	Native copper in serpentine; Aubury places deposit 12 mi. S. of Ukiah. (Aubury, L. E. 05, p. 135; 08, p. 161; Crawford, J. J. 96, p. 59; Lowell, F. L. 16b, p. 418.)
4	D	Ogle		30	13N	12W	MD	Shaft, 16 ft.; shows carbonates. (Lowell, F. L. 16b, p. 419.)
*5	D	Pieta			12N	10W	MD	Open cut in serpentine. (Aubury, L. E. 05, p. 136; Lowell, F. L. 16b, p. 419.)
6	C	Red Mountain (Salina)		23	15N	12W	MD	(Aubury, L. E. 05, p. 135; 08, p. 161; Lowell, F. L. 16b, p. 419.)
7	C	Redwood Copper Queen		17, 20	12N	13W	MD	Kidneys and lenses of pyritic copper ore in a zone 10 to 40 ft. wide, 300 ft. long, 125 ft. deep, in sandstone; largest kidney is 75 ft. long, 8 ft. thick; 400 tons shipped for production of sulphuric acid in 1906. (Aubury, L. E. 05, p. 136; 08, p. 162; Averill, C. V. 29d, p. 462; Lowell, F. L. 16b, pp. 419-420.)
		Salina: see Red Mountain						
8	D	Thomas		9	20N	12W	MD	No vein found. (Aubury, L. E. 05, p. 135; 08, p. 161; Crawford, J. J. 96, p. 59.)
9	D	Whipple		17	14N	14W	MD	Copper carbonate seams in shale. (Averill, C. V. 29d, p. 462.)

* Not shown on map because of lack of definite location.

MERCED COUNTY

Number	Class by production	Name of deposit	Name of owner or operator	Location Sec.	T.	R.	B. & M.	Remarks and references
*1	D	Berg	G. Berg, Panoche, Calif. (1924)	Approx.	8S	17E	MD	Copper-gold-silver mine. (Laizure, C. McK 25, p. 179.)
*2	C	Johnny Green	W. C. Kroh, Le Grand, Calif. (1916)	Approx.	8S	16E	MD	Copper mine.
3	C	Jose		4	13S	9E	MD	Copper mine; small bodies of chalcopyrite with gold; considerable development work. (Aubury, L. E. 05, p. 146; 08, p. 171; Laizure, C. McK 25, p. 179; Lowell, F. L. 16d, p. 605.)
*4	C	Kroh	W. C. Kroh, Le Grand, Calif. (1913)	Approx.	8S	16E	MD	Copper mine.
5	C	Victor Bonanza group		30, 31	13S	10E	MD	Copper mine; chalcopyrite and native copper in croppings; a mineralized belt extends 5 or 6 miles; little development work; small production 1901-04. (Aubury, L. E. 05, p. 146; 08, p. 172; Boalich, E. S. 21c, p. 149; Laizure, C. McK 25, p. 179; Lowell, F. L. 16d, p. 605; Pabst, A. 38, p. 29.)
				14, 15 16, 23 24, 25	13S	9E	MD	

* Not shown on map because of lack of definite location.

MODOC COUNTY

Number	Class by production	Name of deposit	Name of owner or operator	Location Sec.	T.	R.	B. & M.	Remarks and references
1	C	Seitz		18, 19	45N	15E	MD	Copper mine (cuprite, malachite, azurite, native copper); adit 336 ft.; shaft, 90 ft.; on narrow veins in andesite; some ore shipped; active in 1915. (Averill, C. V. 36a, p. 451; Tucker, W. B. 19a, p. 241.)

MONO COUNTY

Number	Class by production	Name of deposit	Name of owner or operator	Location: Sec.	T.	R.	B. & M.	Remarks and references
*1	C	Beckman	Howerton & Richards, Benton, Calif. (1941)	Approx.	4S	31E	MD	Lead-silver mine; also gold.
2	C	Blind Spring Hill	Conway & Minnebery, Benton, Calif. (1935)	18	2S	32E	MD	Antimony-silver mine? Also lead, gold. (Sampson, R. J. 40, p. 118, pl. 1.)
3	C	Blue Bird	J. F. Birchim, Bishop, Calif. (1934)	19	3S	31E	MD	Lead-silver mine; also gold. (Sampson, R. J. 40, p. 118, pl. 1.)
4	C	Casa Diablo	Bartram & Clifford, Laws, Calif. (1942)	21, 22	4S	32E	MD	Gold mine; also lead, silver. (Eakle, A. S. 19a, p. 172; Sampson, R. J. 40, p. 118, pl. 1.)
5	C	Chemung	A. E. Kibble, Reno, Nevada (1943)	20	6N	26E	MD	Gold mine; also silver. (Sampson, R. J. 40, p. 122.)
6	C	Comanche and Kerrick	U. S. Metals Corp., Los Angeles, Calif. (1942)	7, 18, 19	2S	32E	MD	Silver-lead mine; also gold. (Sampson, R. J. 40, pp. 118, 141.)
				13, 24	2S	31E	MD	
*7	C	Crater View	W. L. Benge, Bishop, Calif. (1941)	Approx.	4S	31E	MD	Silver mine.
		Cuba: see Santiago						
*8	-------	Curtin	W. J. Curtin, Bishop, Calif. (1912)	Approx.	5S	33E	MD	Lead-silver mine.
9	C	Eva Bell	J. C. McMillan, Los Angeles, Calif. (1929)	35	4S	34E	MD	Lead-silver mine; also gold.
*10	C	Green Monster	Molini Bros., Dyer, Nevada (1940)	Approx.	2S	33E	MD	Lead-silver mine; also gold.
11	C	Goleta Consolidated	Goleta Cons. Mining Co. (1940)	11	2N	25E	MD	Gold-silver-copper mine; a 6-ft. vein of copper ore on hanging wall of gold-silver vein; adit 200 ft. (Aubury, L. E. 05, p. 243; 08, p. 299; Sampson, R. J. 40, p. 124.)
*12	C	Hammil & Pedro	Hammil & Pedro, Benton, Calif. (1913)	Approx.	2S	31E	MD	Copper mine.
		Havana: see Santiago						
*13	C	Homestead	J. Merkert, Mono, Calif. (1919)	Approx.	2S	31E	MD	Silver mine; also gold.
14	C	Hudson	W. Jones, Benton, Calif. (1942)	18	2S	32E	MD	Lead-silver mine. (Ransome, A. L. 40, p. 175; Sampson, R. J. 40, p. 118.)

MONO COUNTY—Continued

Number	Class by production	Name of deposit	Name of owner or operator	Location				Remarks and references
				Sec.	T.	R.	B. & M.	
		Kentuck: see Silverado-Kentuck						
		Kerrick: see Comanche & Kerrick						
15	C	Long Chance & Vanelmart	H. A. Van Loon, Bishop, Calif. (1935)	35	3S	31E?	MD	Lead-silver mine; also gold.
*16	C	Mahle	C. Mahle, Benton, Calif. (1926)	Approx.	2S	31E	MD	Lead-silver mine; also gold.
17	C	Mammoth	Mono Mammoth Mines, Inc., Mammoth Lakes, Calif. (1941)	9, 10 15, 16	4S	27E	MD	Gold mine; also lead, silver. (Sampson, R. J. 40, pp. 118, 127.)
18	C	May Lundy	R. T. Hanna, Martinez, Calif. (1940)	30	2N	25E	MD	Gold mine; also lead, silver. (Tucker, W. B. 40, p. 46.)
*19	C	McLean		Approx.	2S	31E	MD	Lead-silver mine.
*20	C	Mono	J. M. Taylor, Bodie, Calif. (1912)	Approx.	4N	27E	MD	Gold-silver mine.
*21	C	Montecito	M. Stegar, Bishop, Calif. (1941)	Approx.	5S	33E	MD	Lead-silver mine; also gold.
		Pedro: see Hammil & Pedro						
*22	C	Powell	L. Flaxa, Benton, Calif. (1942)	Approx.	2S	31E	MD	Lead-silver mine; also gold.
*23	C	Quail	W. H. Davis, Benton, Calif. (1921)	Approx.	2S	31E	MD	Gold-silver mine.
24	C	Recovery	H. L. Hager, Benton, Calif. (1935)	24?	2S	31E	MD	Lead-silver mine; also gold.
		Red Cloud: see Standard						
25	C	Sacramento	J. B. Smith, Laws, Calif. (1941)	2, 11	5S	33E	MD	Gold mine; also lead, silver. (Sampson, R. J. 40, pp. 118, 132.)
*26	C	St. Ives	Rasmussen & Grunwell, Bishop, Calif. (1936)	Approx.	3S	27E	MD	Lead-silver mine; also gold.
27	D	Santiago (Cuba, Havana)		11	2N	25E	MD	Porphyry-limestone contact; 500-ft. adit; 150-ft. shaft; idle many years. (Aubury, L. E. 05, p. 243; 08, p. 299; Sampson, R. J. 40, p. 120.)

28	C	Sierra Vista	Smith & Jackson, Long Beach, Calif. (1943)	21	4S	31E	MD	Tungsten-gold mine; also lead, silver. (Tucker, W. B. 43, p. 65.)
29	C	Silverado-Kentuck	Sierra Cons. Mines, Inc., Reno, Nevada (1940)	18, 19 30	7N	25E	MD	Silver mine; also lead, gold. (Sampson, R. J. 40, p. 145.)
30	C	Silver Reef	J. G. Main, Benton, Calif. (1940)	13	3S	30E	MD	Lead-silver mine; also gold. (Sampson, R. J. 40, pp. 118, 146.)
31	C	Standard (Red Cloud)	Roseklip Mines Co., San Francisco, Calif. (1942)	9, 16	4N	27E	MD	Gold mine; also silver. (Sampson, R. J. 40, p. 137.)
32	C	Twenty Grand	A. T. Wilkerson, Bishop, Calif. (1936)	14	5S	33E	MD	Gold-lead-silver mine. (Sampson, R. J. 40, pp. 118, 139.)
		Vanelmart: see Long Chance and Vanelmart						
*33	C	West	J. Conte, Laws, Calif. (1933)	Approx.	4S	32E	MD	Lead-silver mine; also gold.

* Not shown on map because of lack of definite location.

MONTEREY COUNTY

Number	Class by production	Name of deposit	Name of owner or operator	Location				Remarks and references
				Sec.	T.	R.	B. & M.	
1	D	Bedell	L. E. Bedell, Parkfield, Calif. (1924)	21	23S	15E	MD	Copper mine; oxidized copper minerals in serpentine. (Laizure, C. McK 25d, p. 31; Waring, C. A. 19c, p. 598.)
2	D	Chualar	c/o Claude C. Kline, 1446 Washington St., San Francisco, Calif, (1943)	10, 11 14, 15 22, 23	15S	5E	MD	Copper mine; two mineralized zones 8-14 ft., over a mile long; in quartzite, granite, and limestone; adit 300 ft.; shaft 90 ft.; assays said to range from 1.67 to 19% copper.
*3	D	Hammond	F. C. Hammond (1922)	Approx.	20S	4E	MD	Gold-copper mine. (Laizure, C. McK 25d, pp. 31, 40.)
4	D	Native Copper	Native Copper Co., Coalinga, Calif. (1924)	26	23S	15E	MD	Copper mine (native copper in serpentine); adits. (Laizure, C. McK 25d, p. 31; Waring, C. A. 19c, p. 598.)
5	D?	Riley Ranch	J. F. and J. T. Riley, Salinas, Calif. (1924)	7, 8	15S	6E	MD	Arsenic-copper mine, near Chualar mine; arsenopyrite, azurite, malachite, magnetite, in limestone at contact of igneous rock; contact metamorphic?

* Not shown on map because of lack of definite location.

NAPA COUNTY

Number	Class by production	Name of deposit	Name of owner or operator	Location: Sec.	Location: T.	Location: R.	Location: B. & M.	Remarks and references
		Grigsby: see Palisade						
1	D	Juniper group		1	11N	5W	MD	(Bradley, W. W. 16, p. 269.)
2	D	Napa Copper		17	10N	5W	MD	Mineralized zone in serpentine; 400-ft. adit, 50-ft. shaft. (Aubury, L. E. 05, p. 140; 08, p. 165; Averill, C. V. 29a, p. 217; Bradley, W. W. 16, p. 269.)
3	C	Palisade (Grigsby)	Palisades Mines Co., Calistoga, Calif. (1941)	24	9N	7W	MD	Silver mine; also gold, lead. (Averill, C. V. 29a, p. 237; Boalich, E. S. 21e, pp. 158-159.)
4	D	Search group		5	6N	5W	MD	Float near mineralized serpentine. (Aubury, L. E. 05, p. 140; 08, p. 165; Averill, C. V. 29a, p. 217; Bradley, W. W. 16, p. 269.)
5	D	White Rock		1	11N	5W	MD	(Averill, C. V. 29a, p. 217; Bradley, W. W. 16, p. 269.)

NEVADA COUNTY

Number	Class by production	Name of deposit	Name of owner or operator	Location: Sec.	Location: T.	Location: R.	Location: B. & M.	Remarks and references
1	C	Arctic	Kemerer Exploration Co., Eureka, Utah (1941)	2 35	17N 18N	11E 11E	MD MD	Gold mine; also silver, lead. (Logan, C. A. 41, p. 444.)
2	C	Arkansas Traveler (also see Mineral Hill)	H. C. Lewis, North Bloomfield, Calif. (1941)	13	15N	6E	MD	Copper mine; production from secondary sulphide zone; ore contains zinc. (Aubury, L. E. 05, p. 169; 08, p. 197; Forstner, W. 08, p. 745; Logan, C. A. 41, p. 444; MacBoyle, E. 19, pp. 81-82.)
3	C	Berkeley		6, 7	16N	8E	MD	Copper mine, secondary ore; 60-ft. shaft (1919); discovered 1904, worked 1913. (Logan, C. A. 41, p. 445; MacBoyle, E. 19, p. 82.)
4	D	Big Bend		25, 36	17N	7E	MD	Copper mine; gossan over 100 ft. wide in places. (Aubury, L. E. 08, p. 199; Logan, C. A. 41, p. 445; MacBoyle, E. 19, p. 82.)
5	C	Bitner group (also see Mineral Hill group)	Chas. Staples?	13	15N	6E	MD	Copper mine. (Logan, C. A. 41, p. 445.)

6	B	Boss (San Juan)	F. W. Bradley, 1022 Crocker Bldg., San Francisco, Calif. (1943)	1, 12 6, 7	17N 17N	7E 8E	MD MD	Copper mine; also gold, silver, lead. (Logan, C. A. 41 p. 446.)
7	C?	California Gold and Copper (also see Mineral Hill)	D. L. Evans, agent, Malad City, Idaho (1941)	12, 13	15N	6E	MD	Gold-copper mine. (Logan, C. A. 41, p. 447.)
8	C	Canada Hill	R. W. Gaylord, Sacramento Calif. (1941)	17	16N	9E	MD	Gold mine; also lead, silver. (Logan, C. A. 41, p. 447.)
9	C	Carlisle		4	17N	13E	MD	Copper mine; 1,300 ft. of adits; vein 2 to 10 ft. wide. (Aubury, L. E. 08, p. 202; Logan, C. A. 41, p. 447; MacBoyle, E. 19, p. 35.)
10	C	Cedar	F. S. Parker, Wolf Rt., Auburn, Calif. (1941)	20, 29	14N	8E	MD	Gold mine; schist strikes N. 60° W.; strong quartz vein crosscuts sulphide zone. (Knopf, A. 06, pp. 411-412; Logan, C. A. 41, p. 447.)
11	C	Champion	C. P. Jones, Grass Valley, Calif. (1935)	1 35	15N 16N	8E 8E	MD MD	Gold mine; also silver, lead. (Logan, C. A. 41, p. 447.)
°12	C?	Copper claim (Spenceville?)	J. G. Berryhill, 24 California St., San Francisco, Calif. (1943)	25, 26 35	15N	6E	MD	Copper mine. (Logan, C. A. 41, p. 448.)
		Dull: see Empress						
13	D	Edison		6	17N	10E	MD	Shaft, 45 ft.; adit 240 ft. (Aubury, L. E. 05, p. 171; 08, p. 198.)
14	B	Empire	Newmont Mining Co., Nevada City, Calif. (1935)	26, 27 34, 35	16N	8E	MD	Gold mine; also silver, lead; now part of Empire-North Star. (Logan, C. A. 41, p. 450.)
15	B	Empress (Dull, Mulcahy, Newtown)	E. J. Rector estate, Nevada City, Calif. (1939)	8, 17	16N	8E	MD	Gold mine; also silver, lead. (Logan, C. A. 41, pp. 350-397.)
16	C	English Mountain	H. C. Shroeder estate, Nevada City, Calif. (1941)	6	18N	13E	MD	
		Eureka Consolidated: see Green Lead						
18	C	Fairview	C. W. Wilson, Nevada City, Calif. (1911)	2	17N	10E	MD	Copper mine; also gold; 375-ft. adit, 170 ft. of backs; 12-ft. vein; 1.1% Cu; 160 acres.
19	C	Frederic	Wiljobar Corp., New York, N.Y. (1935)	4	16N	9E	MD	Gold mine?
20	D	Gautier Ranch		28, 29	14N	8E	MD	Copper mine; 80-ft. shaft. (Aubury, L. E. 08, p. 203; Logan, C. A. 41 p. 451; MacBoyle, E. 19, p. 86.)
21	C	Giant King	Washington Giant King Mines Inc., Nevada City, Calif. (1939)	13	17N	10E	MD	Gold mine; also silver, lead. (Logan, C. A. 41, p. 451.)
22	C	Golden Center	Cooley Butler, Los Angeles, Calif. (1942)	27	16N	8E	MD	Gold mine; also silver, lead. (Logan, C. A. 41, p. 452.)
		Gracie: see Gracie Glencoe						

NEVADA COUNTY—Continued

Number	Class by production	Name of deposit	Name of owner or operator	Location Sec.	T.	R.	B. & M.	Remarks and references
23	C	Gracie Gleneoe (Gracie)	Gracie Mines, Inc., Nevada City, Calif. (1939)	18	16N	9E	MD	Gold mine; also lead, silver. (Logan, C. A. 41, p. 452.)
*24	C	Great Ironclad	H. M. Black, Grass Valley, Calif. (1911)					Gold mine?
		Great Northern: see Hoge						
25	C	Greenhorn Creek	J. Larghero, Nevada City, Calif. (1941)	19	16N	10E	MD	Gold mine. (Logan, C. A. 41, p. 453.)
26	C	Green Lead (Eureka Consolidated)	Mary E. Mooney, agent, Smartsville, Calif. (1941)	1, 12	15N	6E	MD	Copper mine. (Aubury, L. E. 08, pp. 195-196; Logan, C. A. 41, p. 450; MacBoyle, E. 19, p. 85.)
27	C	Green Mountain	Kistle Bros., Nevada City, Calif. (1936)	1 35	15N 16N	8E 8E	MD MD	Gold mine; also lead, silver. (Logan, C. A. 41, p. 453.)
28	D	Hibber		32	14N	7E	MD	Gossan 3 ft. wide, 400 ft. long; 2-ft. vein. (Aubury, L. E. 05, p. 167; 08, p. 195.)
29	C	Hoge (Great Northern)	Great Northern Mines, Nevada City, Calif. (1941)	4	16N	9E	MD	Gold mine; also silver, lead. (Logan, C. A. 41, p. 453.)
30	C	Hussey (Hussey Ledge)	H. H. Hussey, Nevada City, Calif. (1941)	4	16N	9E	MD	Gold mine; also lead, silver. (Logan, C. A. 41, p. 454.)
31	C	Idaho Maryland	Idaho Maryland Cons. Mines Co., Grass Valley, Calif. (1944)	23, 24 25, 26 36	16N	8E	MD	Gold mine; also silver, lead. (Logan, C. A. 41, p. 454.)
32	B	Imperial Paint and Copper		26, 35	15N	6E	MD	Probably same as "Copper claim"; produced cement copper and red paint during nineties. (Crawford, J. J. 94, p. 67; 96, p. 60; Logan, C. A. 30, p. 95.)
33	B?	Last Chance (also see Mineral Hill group)	Charles Staples, Spenceville, Calif. (1941)	12, 13	15N	6E	MD	Copper mine. (Logan, C. A. 41, p. 456.)
34	B	Lava Cap	Lava Cap Gold Mining Co., Nevada City, Calif. (1943)	16, 21 28	16N	9E	MD	Gold mine; also lead, silver. (Logan, C. A. 41, p. 456.)
*35	C	Lone Pine	C. Trevethick et al., Grass Valley, Calif. (1940)					Gold mine; also silver, lead.
36	D	Lotzen Ranch		2	14N	7E	MD	Copper mine; 60-ft. adit; 16-ft. vein, strike N. 30° W., dip 85° SW. (Aubury, L. E. 08, p. 204; Logan, C. A. 41, p. 456; MacBoyle, E. 19, p. 86.)

37	C	McDonald Ranch	C. Linteeum, Grass Valley, Calif. (1941)	3, 4	15N	8E	MD	Copper mine; also gold, silver.
38	D	Mammoth Gold Copper		12	17N	7E	MD	Gold-copper mine; 40-ft. adit. (Aubury, L. E. 08, p. 204; Logan, C. A. 41, p. 457; MacBoyle, E. 19, p. 87.)
39	B	Mineral Hill group (Monmouth-Climax, Western Copper; see also Arkansas Traveler, Bitner, California Gold & Copper, Last Chance)	Charles Staples, Spenceville, Calif. (1941)	13	15N	6E	MD	Copper mine. (Logan, C. A. 41, p. 457; 24, p. 12.)
		Monmouth-Climax: see Mineral Hill group						
		Mulcahy: see Empress						
40	B	Murchie	Empire Star Mines Co., Ltd., Grass Valley, Calif. (1941)	8, 9 16, 17	16N	9E	MD	Gold mine; also silver, lead; copper by-product. (Logan, C. A. 41, p. 458.)
		Newtown: see Empress						
42	D	Nickerson Ranch		29	14N	8E	MD	Adit 200-ft.; two veins; heavy sulphide. (Aubury, L. E. 05, p. 166; 08, p. 194.)
43	C	Norambagua (Three Sevens)	Grass Valley, Gold, Inc., Grass Valley, Calif. (1938)	11, 15	15N	8E	MD	Gold mine. (Logan, C. A. 41, p. 459.)
44	C	North Star	Empire Star Mines Co., Ltd., Grass Valley, Calif. (1941)	2, 3 27, 28 34	15N 16N	8E 8E	MD MD	Gold mine; also silver, lead. (Logan, C. A. 41, p. 460.)
45	C	Orleans	Orleans Lode Mining Co., Nevada City, Calif. (1936)	1 35	15N 16N	8E 8E	MD MD	Gold mine; also lead, silver. (Logan, C. A. 41, p. 461.)
46	C	Oro Grande		27	18N	13E	MD	Copper mine; a gossan gold mine in eighties; 20 parallel veins, cropping 4,500 ft. (Aubury, L. E. 08, p. 199; Logan, C. A. 41, p. 461; MacBoyle E. 19, p. 58.)
47	C	Pine Hill	Ira J. Coe, 67 Santa Clara Ave., Oakland, Calif. (1941)	12	14N	7E	MD	Gold-copper mine. (Lindgren, W. 92, pp. 92-96; Logan, C. A. 41, p. 461.)
48	C	Queen Lil	R. Buffington, Nevada City, Calif. (1941)	11	16N	8E	MD	Gold mine; also lead, silver. (Logan, C. A. 41, p. 462.)
*49	D?	Queen Regent						Copper-gold mine. (Logan, C. A. 41, p. 462.)
50	C	Ragon	California Sierra Gold Mines Inc., Nevada City, Calif. (1937)	2	16N	8E	MD	Gold mine; also lead, silver. (Logan, C. A. 41, p. 462.)
51	C	Randolph	A. W. Davis, Nevada City, Calif. (1940)	32	17N	9E	MD	Gold mine; also silver, lead. (Logan, C. A. 41, p. 462.)

NEVADA COUNTY—Continued

Number	Class by production	Name of deposit	Name of owner or operator	Location Sec.	T.	R.	B. & M.	Remarks and references
52	C	Red Ledge	South Yuba Mining & Smelting Co., A. A. Ellinger, agent, 863 High St., San Francisco, Calif. (1941)	35, 36	17N	7E	MD	Gold mine; wide gossan in early days; strike N. 45° W., dip 60° W. (Aubury, L. E. 08, p. 200; Logan, C. A. 41, p. 462; MacBoyle, E. 19, p. 89.)
53	D	Red Mountain group		17	17N	13E	MD	Copper mine; 30-ft. adit. (Aubury, L. E. 08, p. 200; Logna, C. A. 41, p. 462.)
		San Juan: see Boss						
54	B	Spanish	San Francisco Commercial Co., 1022 Crocker Bldg., San Francisco, Calif. (1943)	19, 30 31	18N	11E	MD	Gold mine; also silver, zinc, lead, copper. (Logan, C. A. 41, p. 464.)
55	A	Spenceville (Copper Claim?, Spence Mineral)	J. G. Berryhill, 24 California St., San Francisco, Calif. (1943)	25, 26 27, 35	15N	6E	MD	Copper mine; also paint and sulphuric acid products; large open pit; shaft (now caved) with at least three levels, 50, 100, and 150 ft. (Logan, C. A. 41, p. 464; 30, p. 95.)
56	C	Spring Hill	Spring Hill Gold Mines, Inc., San Francisco, Calif. (1943)	23, 24 25, 26	16N	8E	MD	Gold mine; also silver. (Logan, C. A. 41, p. 464.)
57	C	Stockton Hill	Stockton Hill Corp., Reno, Nevada (1941)	9	14N	8E	MD	Gold mine; also silver. (Logan, C. A. 41, p. 465.)
58	D	Sweet Ranch		13	14N	7E	MD	Gold mine; also barite; heavy, gold-bearing gossan. (Aubury, L. E. 08, p. 201; Logan, C. A. 41, p. 465.)
59	C	Taylor iron mine	C. H. Taylor, Grass Valley, Calif. (1941)	3	15N	7E	MD	Shaft, 250 ft.; drifts, 2,300 ft.; ore 33% S, 67% Fe, some copper. (Aubury, L. E. 08, p. 203; Logan, C. A. 41, p. 454.)
		Three Sevens: see Norambagua						
60	D	Tola group	J. E. Anderson, Box 5, Auburn, Calif. (1941)	26, 27 34, 35	18N	13E	MD	Copper mine; cuts, pits. (Aubury, L. E. 08, p. 201; Logan, C. A. 41, p. 466; MacBoyle, E. 19, p. 91.)
61	D	Turner group		16	18N	13E	MD	Copper mine; 18-ft. shaft; vein strikes SW., dips W. (Aubury, L. E. 08, p. 201; Logan, C. A. 41, p. 466; MacBoyle, E. 19, p. 91.)
		Western Copper: see Mineral Hill						
62	D	Wetteran Ranch		34	15N	7E	MD	Copper mine; 20-ft. shaft. (Aubury, L. E. 08, p. 201; Logan, C. A. 41, p. 467; MacBoyle, E. 19, p. 91.)

* Not shown on map because of lack of definite location.
° Not shown on map because of crowded condition.

ORANGE COUNTY

Number	Class by production	Name of deposit	Name of owner or operator	Location: Sec.	T.	R.	B. & M.	Remarks and references
1	C	Blue Light (Silverado)	Blue Light Mines Corp., Anaheim, Calif. (1944)	11, 14	5S	7W	SB	Lead-zinc-silver mine; also gold. (Tucker, W. B. 43a, p. 122.)
		Old Dominion: see Ortega						
2	C	Ortega (Old Dominion)	Ortega Mining Co, Santa Ana, Calif. (1942)	7	6S	5W	SB	Lead-zinc-silver mine. (Tucker, W. B. 43a, p. 123.)
		Silverado: see Blue Light						

PLACER COUNTY

Number	Class by production	Name of deposit	Name of owner or operator	Location: Sec.	T.	R.	B. & M.	Remarks and references
*1	C		Ward & Ward (BB) (1941)	Approx.	12N	8E	MD	Gold mine; also lead, silver.
*2	C		R. H. Nelson, Auburn, Calif. (1943)	Approx.	12N	8E	MD	Copper mine? Also lead, silver.
3	C	Alabama	Alabama California Gold Mines Co., Auburn, Calif. (1942)	35	12N	7E	MD	Gold mine; also silver, lead. (Logan, C. A. 36, p. 42.)
4	C	Algol (Argall?)	Nevada Irrigation District	9	13N	7E	MD	Two 120-ft. shafts, 200-ft. drift, worked in sixties; 10 carloads shipped 1901. (Aubury, L. E. 05, p. 173; 08, pp. 207-208; Logan, C. A. 27a. p. 247; Waring, C. A. 19a, p. 327.)
5	D	Argall (Argol, Algol?)		3	13N	7E	MD	
*6	C	Arkansas Traveler	H. C. Lewis, Colfax, Calif. (1943)	Approx.	15N	10E	MD	Gold mine; also silver.
7	C	Auburn-Chicago (Chicago)	Auburn Chicago Mining Co., Auburn, Calif. (1938)	35, 36	12N	7E	MD	Gold mine; also silver, lead. (Logan, C. A. 36, p. 42.)
8	C	Auburn-Pacific	Auburn-Pacific Mines, Inc., Auburn, Calif. (1937)	12	12N	7E	MD	Gold mine; also silver, lead.
9	C	Big Pine (T.W.A.)	A. N. Sweet, Auburn, Calif. (1935)	16	12N	8E	MD	Gold-silver-lead mine; shaft 170 ft. (Aubury, L. E. 05, p. 174; 08, p. 210; Logan, C. A. 27a, p. 247; 36, p. 39; Waring, C. A. 19a, p. 327.)

PLACER COUNTY—Continued

Number	Class by production	Name of deposit	Name of owner or operator	Location				Remarks and references
				Sec.	T.	R.	B. & M.	
10	C	Blue Eagle (June Bug)	H. Livingston, Auburn, Calif. (1939)	18	12N	8E	MD	Gold mine; also silver, lead. (Logan, C. A. 36, p. 14.)
11	C?	Bobtail	W. Recknagel, Auburn, Calif. (1935)	18	13N	7E	MD	Gold prospect, with a little chalcopyrite. (Logan, C. A. 36, p. 43; Waring, C. A. 19a, p. 334.)
12	D	Casey		10	13N	8E	MD	
		Chicago: see Auburn-Chicago						
13	A	Dairy Farm (Trent, Vantrent)	Dairy Farm Gold Corp., Lincoln, Calif. (1936); Vantrent Mining Co., Lincoln, Calif. (1917)	27	14N	6E	MD	Copper-gold mine; also silver; paint, sulphuric acid; lens of pyrite with some chalcopyrite; large open pit, also a 590-ft. shaft inclined about 60°; main levels at 100, 200, 300, 400, and 500 ft.; produced 1904-05, 1918, 1922. (Aubury, L. E. 08, pp. 208-209; Forstner, W. 08, p. 745; Harding, J. E. 17, p. 491; Knopf, A. 06, p. 414; Lindgren, W. 09, p. 141; Logan, C. A. 27a, p. 246; 36, pp. 19-20, 44; Tolman, C. F. 35, pp. 247-250; Waring, C. A. 19a, pp. 327-328; Weed, W. H. 16, pp. 425-426.)
14	D	Davenport		15	12N	8E	MD	Shaft 70 ft.; ore body 2 ft. wide. (Aubury, L. E. 08, p. 209; Logan, C. A. 27a, p. 247; Waring, C. A. 19a, p. 328.)
15	C	Eclipse Consolidated	Ophir Nevada Mining & Milling Co., Auburn, Calif. (1940)	17	12N	8E	MD	Gold mine; also lead, zinc, copper, silver; shafts 280, 200, 100 ft.; drifts 540 ft.; strong gossan. (Aubury, L. E. 08, p. 207.)
16	D	Elder		4	13N	6E	MD	Copper stains; a little molybdenite in granite. (Aubury, L. E. 08, p. 210; Logan, C. A. 27a, p. 247; Waring, C. A. 19a, p. 329.)
		Gaylord: see Landis and Gaylord						
17	C	Globe Consolidated		8	12N	8E	MD	Shaft 250 ft.; produced in 1916. (Logan, C. A. 27a, p. 247; Waring, C. A. 19a, pp. 327-328.)
18	C	Golden Acacia	G. Giavani, Auburn, Calif. (1940)	16	12N	8E	MD	Gold mine; also silver.
19	C	Green Emigrant	Mrs. J. C. Thomas, Oakland, (1935)	29	13N	8E	MD	Gold mine. (Logan, C. A. 36, p. 45.)
*20	D	Greenhorn			15N	9E	MD	Disseminated sulphides. (Logan, C. A. 27a, p. 247; Waring, C. A. 19a, p. 329.)
		Harpending: see Valley View						
*21	C	Highway Forty	Highway Forty Mines, Inc., Sacramento, Calif. (1942)	Approx.	12N	8E	MD	Gold mine; also silver, lead.
		June Bug: see Blue Eagle						

		Kilaga Springs: see Valley View						
22	C	Lakeview	A. C. Shock, Auburn, Calif.; lessee, Lewis Johnson, Auburn, Calif. (1943)	32	13N	9E	MD	Gold-copper mine; new operation; vein said to be 2,000 ft. long; 4 to 8 ft. wide; shaft 54 ft.; drift 175 ft.; worked since February 1943. (Averill, C. V. 43a, p. 558.)
*23	C	Landis & Gaylord	Landis & Gaylord, Lincoln, Calif. (1916)	Approx.	12N	7E	MD	Gold mine; also silver.
24	C	Lucky Strike	Lucky Strike Mines, Forest Hill, Calif. (1938)	30	13N	8E	MD	Gold mine.
*25	C	Major	Major Bros., Newcastle, Calif. (1914)	Approx.	12N	8E	MD	Gold mine; also lead, silver.
26	D	Nevada Mining Co.		32	14N	8E	MD	Shaft 55 ft.; on county line. (Aubury, L. E. 08, p. 209; Logan, C. A. 27a, p. 247; Waring, C. A. 19a, p. 329.)
27	C	Oest		4	13N	8E	MD	Native copper; small production previous to 1902. (Aubury, L. E. 08, pp. 217-218; Tucker, W. B. 19c, p. 278.)
28	C	Ophir	F. W. Stall, Sacramento, Calif. (1943)	7, 8 17, 18	12N	8E	MD	Gold mine; also silver.
29	C	Oro Fino (Ora Fina)	Oro Fino Cons. Mines, San Francisco, Calif. (1943)	7, 8	12N	8E	MD	Gold mine; also silver, lead. (Logan, C. A. 36, p. 46.)
*30	C	Quail	Quail Mining Co., Vantrent, Calif. (1916)	Approx.	14N	6E	MD	Copper mine; also silver.
31	C	Rawhide	Canyon Mines Corp., Baxter, Calif. (1941)	4	15N	11E	MD	Gold mine; also silver; 5 mi. E. from Towle. (Logan, C. A. 36, p. 47.)
32	C	Sisley	Burm-Ball Mining Co., Auburn, Calif. (1939)	26	12N	7E?	MD	Gold mine; also silver, lead.
*33	C	Slosson	E. P. Slosson, Auburn, Calif. (1918)	Approx.	12N	8E	MD	Gold mine?
°34	D	Thomeau		4, 5	13N	8E	MD	Shaft 90 ft. (Aubury, L. E. 08, p. 209; Logan, C. A. 27a, p. 247; Waring, C. A. 19a, p. 329.)
		Trent: see Dairy Farm						
		T. W. A.: see Big Pine						
35	C	Two Orphans	A. Locatelli, Colfax, Calif. (1936)	30	13N	8E	MD	Gold mine; also silver. (Logan, C. A. 36, p. 48.)
36	A	Valley View (Whiskey Diggings, Harpending, Kilaga Springs)	J. B. Landis, Auburn, Calif.	12, 13 24	13N	6E	MD	Copper mine; also silver, gold, lead; chalcopyrite and pyrite with sphalerite in schistose quartz porphyry in schist; three shafts on property, two vertical, approximately 180 and 280 ft. deep; third is inclined and is 200 ft. deep; there are also two adits and a moderately large open pit. (Aubury, L. E. 05, p. 174; 08, p. 208; Averill, C. V. 43c, p. 558; Graton, L. C. 07, p. 395; Knopf, A. 06, p. 415; Lang, H. 07, p. 264; Logan, C. A. 27, pp. 246-247; Pabst, A. 38, p. 29; Silliman, B. 68, pp. 93-95.)

PLACER COUNTY—Continued

Number	Class by production	Name of deposit	Name of owner or operator	Location Sec.	T.	R.	B. & M.	Remarks and references
37	D	Van Giesen		10	13N	8E	MD	
		Vantrent: see Dairy Farm						
		Whiskey Diggings: see Valley View						
38	C	Wobena (Wubbena)	Wobena Mine, Soda Springs, Calif. (1934)	32	16N	14E	MD	Gold mine; also silver. (Logan, C. A. 36, p. 48.)
		Wubbena: see Wobena						

* Not shown on map because of lack of definite location.
° Not shown on map because of crowded condition.

PLUMAS COUNTY

Number	Class by production	Name of deposit	Name of owner or operator	Location Sec.	T.	R.	B. & M.	Remarks and references
*1	C		H. Dalphin, Walker, Calif. (1943)	Approx.	24N	12E	MD	Copper mine; also silver.
*2	C		H. Michaels Co., Greenville, Calif. (1942)	Approx.	26N	9E	MD	Gold mine; also silver, lead.
*3	C		C. W. Nugen, Butt Valley, Calif. (1941)	Approx.	26N	7E	MD	Gold mine; also silver, lead.
4	D	Austrian Syndicate	Austrian Syndicate Mining & Development Co., c/o A. B. Hill Jr., 14 Montgomery St., San Francisco, Calif.	24	25N	11E	MD	Gold-copper mine. Five patented claims; old workings developed gold and copper in quartz veins. (Averill, C. V. 28a, p. 285; 37, p. 126.)
5	D	Barnes	H. Barnes, Engelmine, Calif. (1937)	32, 33	28N?	11E	MD	Copper mine; north of Engels; adit, 100 ft.; shaft 36 ft. (Averill, C. V. 28, p. 270; 37, p. 126.)
6	C	Beardsley (Telge)	A. L. Beardsley, Los Angeles, Calif. (1937)	14, 15	26N	11E	MD	Copper mine; disseminated ore; shaft 300 ft.; additional workings, over 600 ft.; several parallel veins; small mill, 1924. (Averill, C. V. 28a, p. 270; 37, p. 126; Crawford, J. J. 96, p. 308; Logan, C. A. 21, p. 462; 24, p. 14.)

		Beetle: see Trask & Coffer						
7	D	Big Cliff	Genesee Consolidated Mines Co., Los Angeles, Calif. (1937)	25	26N	11E	MD	Copper mine; large masses blasted from a cliff about 1920 showed disseminated bornite. (Averill, C. V. 28a, p. 270; 37, p. 126.)
8	C	Bill and Helen	A. J. Downey, Crescent Mills, Calif. (1935)	8	27N	11E	MD	Gold mine; also silver.
10	C	Blue Bell	Blue Bell Mining Co. (1937)	2	25N	11E	MD	Gold mine; ore in limestone near granodiorite contact; carbonate copper ore produced in early days; elevation 4200 ft. (Aubury, L. E. 08, p. 155; Averill, C. V. 37, p. 126; Diller, J. S. 08, p. 116; MacBoyle, E. 20a, p. 100.)
11	C	Bonanza and Bobtail	Jacks & Cooksie (1937)	20	27N	11E	MD	Copper mine; part of a car of ore, 7% Cu, 40 oz. Ag shipped from shallow cut. (Averill, C. V. 37, p. 126; Logan, C. A. 21, p. 463.)
		Borden: see Pilot						
		Brandt: see Five Bears						
*12	D	Bull of the Woods			27N	11E	MD	Copper mine; two 50-ft. shafts, 28-ft. vein zone said to run 2% Cu. (Averill, C. V. 28a, p. 270; 37, p. 127.)
13	D	Bullion	A. L. Beardsley, Genesee, Calif. (1937)	14	26N	11E	MD	Gold mine; disseminated sulphide zones as well as gold-quartz veins; discovered in 1851, relocated in 1913; elevation 4500 ft. (Averill, C. V. 37, p. 127.)
14	C	Bullion	Mrs. A. E. Hayden, Reno, Nevada (1937)	29	22N	13E	MD	Gold mine; also silver. (Averill, C. V. 37, p. 127.)
15	C	Butte and Iron Lilly	Mrs. J. D. Williams, Oroville, Calif. (1937)	1	27N	10E	MD	Gold mine; also silver; adits 130 ft., 60 ft., 50 ft.; shaft 22 ft.; quartz-calcite veins with gold and 2.5% Cu; located in 1902; elevation 6000 ft.
16	C	Calnan (Little Joe)	M. J. Calnan, Genesee, Calif. (1936)	11, 14	25N	11E	MD	Gold mine; claims cover old locations; 30 tons sorted ore said to run $300 per ton; no other production. (Averill, C. V. 37, p. 127; Logan, C. A. 21, p. 463.)
		Centennial: see Five Bears						
17	C	Cherokee	Mrs. V. S. Webb, Sacramento, Calif. (1937)	14, 23	26N	9E	MD	Gold mine. (Averill, C. V. 37, p. 127.)
		Coffer: see Trask & Coffer						
18	C	Consolidated Gold and Metals Co. (Walker Cons.)	c/o J. R. Walker, Newhouse Bldg., Salt Lake City, Utah (1936)	1, 11 12	24N	11E	MD	Gold-copper mine; development work done in 1932; 13 samples said to average $5.07 Au, 2½ oz. Ag, 4.06% Cu; 11 claims patented. (Averill, C. V. 37, pp. 93, 128.)
19	C	Copper	Goodhue Bros., Genesee, Calif. (1936)	14	25N	11E	MD	Copper mine, mainly gold? Adits 500, 400 ft.; shaft 200 ft., caved; quartz stringers in andesite; small flotation mill operated in 1928. (Averill, C. V. 28a, pp. 170-271; 37, p. 128.)
		Copper Bull: see Iron Dike						

PLUMAS COUNTY—Continued

Number	Class by production	Name of deposit	Name of owner or operator	Location				Remarks and references
				Sec.	T.	R.	B. & M.	
20	D	Copper Bullion	Wickstrom & Mattson, Quincy, Calif. (1936)	34	23N	10E	MD	Copper mine; a sulphide vein developed by a 30-ft. adit; mine reached by trail. (Averill, C. V. 37, pp. 93, 128.)
21	C	Copper group	T. Lane, Angels Camp, Calif. (1920)	11, 14	25N	11E	MD	Copper mine; tetrahedrite; gold and silver in bunches; two adits and winze; 4-ft. veins. (Averill, C. V. 37, p. 128; Logan, C. A. 21, p. 463.)
22	D	Copper King	Sobrero Bros., Genesee, Calif. (1936)	12, 13	25N	11E	MD	Copper mine; 4% Cu; irregular bodies of copper ore; one body 22 ft. long, 22 ft. wide, 30 ft. deep; elevation, over 5000 ft. (Averill, C. V. 37, p. 128; Logan, C. A. 21, pp. 463-464.)
23	D	Copper King and Copper Queen	W. H. and L. M. Bacon, Eureka, Utah (1936)	21	26N	15E	MD	Copper mine; quartz vein with gossan carrying chalcopyrite and bornite; adit 40 ft.; several shallow shafts; elevation 6300 ft. (Averill, C. V. 37, p. 128; MacBoyle, E. 20a, pp. 54-55.)
		Cosmopolitan: see Reward						
*24	D?	Cottonwood	Carr, Ryan, Barry, et al., Susanville, Calif. (1936)	--------	27N	10E	MD	Copper mine. (Averill, C. V. 28a, p. 313; 37, p. 128.)
25	C	Daley	J. M. Daley, Chilcoot, Calif. (1913)	29	22N	8E	MD	Gold mine. (Averill, C. V. 37, p. 128.)
		Dufay: see El Dorado						
26	C	Duncan	J. B. Duncan, Genesee, Calif. (1936)	31	26N	12E	MD	Gold mine; also copper, silver; high-grade kidneys of bornite with gold and silver on grandodiorite-limestone contact; 600 ft. of adits. (Aubury, L. E. 05, pp. 155-156; Averill, C. V. 37, p. 129; Diller, J. S. 08, pp. 113, 116; MacBoyle, E. 20a, p. 116.)
27	C	El Dorado (Dufay)	Sonognini & Dufay, Chilcoot, Calif. (1936)	25	24N	16E	MD	Copper mine; 200-ft. adit and drift on 4-ft. quartz vein in granite; one car of high-grade copper ore shipped 1909-18. (Averill, C. V. 37, p. 129; MacBoyle, E. 20a, pp. 55, 180.)
28	A	Engels: see also Superior	Engels Copper Mining Co., 364 Mills Bldg., San Francisco, Calif.	3, 4, 5 8, 9, 10 32, 33 34	27N 28N	11E 11E	MD MD	Copper mine; also gold, silver; chalcopyrite, bornite, magnetite, and ilmenite in breccia, at contact of gabbro and quartz diorite; pyrite rare. (Anderson, C. A. 30, pp. 14-35; 31, pp. 293-330; Aubury, L. E. 08, pp. 185-186; Averill, C. V. 28a, pp. 273-278; 37, p. 130; Donnay, J. D. H. 29, pp. 77-80; 31, pp. 99-111; Fenner, C. N. 30, pp. 420-425; 31; Graton, L. C. 17, pp. 1-38; 18, pp. 81-99; Greig, T. W. 32, pp. 25-33; Logan, C. A. 21, pp. 464-466; 24, p. 14; Neale, W. G. 27, pp. 470-473; Nelson, W. I. 30, pp. 673-705; 32, pp. 1-23; Rand, L. H. 31, p. 552; Tolman, C. F. Jr. 17, pp. 379-386; Turner, H. W. 14, pp. 359-391; 21, pp. 333-334.)
29	C	Five Bears (Centennial, Brandt)	Five Bears Mining Co., Quincy, Calif. (1941); H. F. Meidinger, 8115 Maryland Ave., Chicago, Illinois (1936)	23, 25	25N	11E	MD	Gold mine; also silver; adit 1400 ft; began as gossan gold mine; gold production $32,000; sulphide zone carries 2.6% Cu. (Averill, C. V. 37, p. 130; Crawford, J. J. 96, p. 290; Logan, C. A. 21, p. 466.)

*30	D	Folsom and Hunter			27N	11E	MD	Copper mine, located in 1916; 30-ft. adit. (Averill, C. V. 37, p. 130; MacBoyle, E. 20a, p. 59.)
*31	D	Fordham		Approx.	22N	9E	MD	Copper mine, 3-12% Cu; large mineralized outcrop; no development. (Averill, C. V. 37, p. 130; MacBoyle, E. 20a, p. 59.)
		Genesee: see Gruss						
		Genesee Valley: see Gruss						
32	C	Golden Horseshoe (Novak)	J. B. Novak, Eureka, Utah (1936)	21, 28	26N	15E	MD	Copper mine; shaft 120 ft.; drift 75 ft.; adit 125 ft.; quartz vein 4 ft. wide in diorite; 3-5% Cu; production in 1915. (Averill, C. V. 37, p. 131; MacBoyle, E. 20a, pp. 59-60.)
*33	D	Greenwood	T. Carr, Susanville, Calif. (1936)		27N	11E	MD	Copper mine; numerous cuts expose sulphide zone; adjoins Engels. (Averill, C. V. 28a, p. 278; 37, p. 131.)
34	C	Gruss (Genesee, Genesee Valley, Ward)	L. M. Tobin, Taylorsville, Calif. (1940)	14, 15	25N	11E	MD	Gold-copper mine; also silver; several hundred feet of workings; 400-ft. shaft; produced copper in early days; gold during 1890's; production $460,000, mostly in gold (1918). (Averill, C. V. 37, p. 130; Crawford, J. J. 96, p. 295; Preston, E. B. 90d, p. 476.)
*35	C	Harris	S. R. Harris, Chilcoot, Calif. (1915)	Approx.	22N	16E	MD	Gold mine; also silver.
36	C	Hinchman (Polar, North Star)	Genesee Cons. Mines Co., Los Angeles, Calif. (1936)	6	25N	11E	MD	Copper-gold mine; bornite ore up to 10% Cu; adit 500 ft.; 2-ft. vein; discovered 1860; surface ore shipped in early days; idle since 1920. (Averill, C. V. 28a, p. 278; 37, p. 131; MacBoyle, E. 20a, pp. 127-128.)
°37	D	Husselman and Shaw	Husselman & Shaw, Susanville, Calif. (1936)	1, 12, 13 6, 7, 8	27N 27N	10E 11E	MD MD	Gold mine; also copper (bornite); adits 197 ft., 150 ft. 85 ft.; other workings; work done before 1902; widest vein 13 ft. (Aubury, L. E. 05, pp. 159-161; Averill, C. V. 37, p. 132; MacBoyle, E. 20a, pp. 130-132.)
38	C	Iron Dike (Copper Bull, Iron Dyke, Montgomery)	F. D. Beardsley, Santa Cruz, Calif. (1936)	2 33, 34	25N 26N	10E 10E	MD MD	Copper mine; principal copper prospect in sixties; quartz with chalcopyrite; four veins or more; 700-ft. adit; other workings; last work done in early 1930's. (Averill, C. V. 28a, pp. 278-279; 37, pp. 95, 132; MacBoyle, E. 20a, p. 135; Preston, E. B. 90d, p. 475.)
		Last Chance: see Mohawk						
		Lena: see U. S. Smelting, Refining, & Mining Co.						
39	D	Little Gem		23	25N	11E	MD	Gold mine; shaft; vein 6 to 18 in. (Aubury, L. E. 05, p. 156; 08, p. 184; Averill, C. V. 37, p. 133; MacBoyle, E. 20a, p. 140.)
		Little Joe: see Calnan						
40	D	Littlefield	F. N. Littlefield, Greenville, Calif. (1936)	33	27N	8E	MD	Copper mine; adits 50, 30, and 30 ft.; on quartz vein with chalcopyrite; dumps said to contain 4% Cu. (Averill, C. V. 28a, p. 279; 37, p. 133.)
*41	D?	Lucky Boy			27N	10E	MD	Copper mine; prospected by diamond drill; 1% Cu ore blocked out. (Averill, C. V. 28a, p. 279; 37, p. 133.)

PLUMAS COUNTY—Continued

Number	Class by production	Name of deposit	Name of owner or operator	Location Sec.	T.	R.	B. & M.	Remarks and references
42	C	Lucky Strike	A. E. Darby, Bucks Ranch, Calif. (1936)	4, 5	23N	7E	MD	Gold mine. (Averill, C. V. 37, p. 133.)
43	B	Mohawk (Last Chance)	Mrs. H. G. Langworthy, Hotel Golden, Reno, Nevada (1936)	25	24N	16E	MD	Copper mine; also silver, molybdenite; shaft 180 ft.; levels 50, 120, and 180 ft.; about 600 ft. of drifts and crosscuts; parallel veins in granite, 4 to 16 ft. wide; 160 acres patented; elevation 6258 ft.; 1000 tons 6% Cu shipped 1913. (Averill, C. V. 37, p. 133; MacBoyle, E. 20a, pp. 60-61.)
		Montgomery: see Iron Dike						
		Moonlight: see Trask & Coffer						
44	C	Mordine and Moraine	Mordine & Moraine, Genesee, Calif. (1913)	5	24N	7E	MD	Gold mine; also silver.
		Morning Star: see Robinson						
45	D	Mountain Lion	Genesee Cons. Mines, Los Angeles, Calif. (1936)	15, 22	25N	11E	MD	Gold mine, mainly gold-quartz; 750-ft. adit. (Averill, C. V. 37, p. 134; MacBoyle, E. 20a, p. 147.)
46	B	Murdock (Plumas Jumbo): see also Mohawk	Mrs. H. G. Langworthy, Hotel Golden, Reno, Nevada (1936)	25 30	24N 24N	16E 17E	MD MD	Copper-molybdenum mine; also silver; shaft 104 ft.; 140-ft. drift at bottom; adits 300, 125 ft.; 42-ft. shaft; 90 tons sorted ore, 6% Cu, shipped; series of parallel veins in granite, average width 4 ft. (Averill, C. V. 37, p. 134; MacBoyle, E. 20a, pp. 61-62.)
47	D?	Native Son	G. & L. Mining Co., Reno, Nevada (1936)	24	25N	11E	MD	Copper mine. (Averill, C. V. 37, p. 134.)
		North Star: see Hinchman						
		Novak: see Golden Horseshoe						
48	C	Ohio	Virgilia Mining Corp., Virgilia, Calif. (1942)	19	24N	11E	MD	Gold mine; also silver, lead.
49	C	Peter	Arthur Peter, Taylorsville, Calif. (1936)	7	26N	11E	MD	Gold mine; also copper (bornite); 2 to 3% Cu in well-defined vein 5-15 ft. wide; 1700 ft. of workings; worked for gold since 1867. (Aubury, L. E. 08, p. 184; Averill, C. V. 37, p. 135; MacBoyle, E. 20a, p. 157.)
50	C	Pilot (Borden)	J. W. Goodhue, Taylorsville, Calif. (1943)	14, 15	25N	11E	MD	Copper mine; also gold, silver; 600 ft. of adits; stope 18 x 4 x 12 ft.; sorted shipment 17% Cu, $14 Au, 14 oz. Ag; worked with arrastra in early days; last work 1922. (Averill, C. V. 28a, pp. 279-280; 37, p. 135; Logan, C. A. 21, p. 468.)
51	C	Plinco	Plinco Copper Mining & Milling Co., Doyle, Calif. (1919)	21	26N	15E	MD	Gold mine ;also silver.

52	C	Plumas-Eureka	C. A. Lundy, Blairsden, Calif. (1944)	26	22N	11E	MD	Gold mine; also silver, lead. (Averill, C. V. 37, p. 135.)
		Plumas Jumbo: see Murdock						
53	D	Pocahontas		12	22N	6E	MD	Copper mine; also silver; native silver, copper, and millerite; two 40-ft. adits; shafts 30 and 40 ft. (Averill, C. V. 37, p. 135; Crawford, J. J. 94, p. 69; MacBoyle, E. 20a, p. 158.)
		Polar: see Hinchman						
54	D	Polar Star		15	25N	11E	MD	Copper mine; adit and open cut. (Averill, C. V. 37, p. 135; MacBoyle, E. 20a, p. 162.)
°55	D	Reinmiller		8	27N	11E	MD	Copper mine; in 1920 a shaft was sunk 65 ft.; adit 70 ft.; and several shorter adits. (Averill, C. V. 37, p. 136; Logan, C. A. 21, pp. 468-469.)
56	B	Reward (Cosmopolitan)	I. L. Rosenthal, 117 Post St., San Francisco, Calif. (1936)	34 3	26N 25N	11E 11E	MD MD	Copper mine; solid bodies of bornite, chalcopyrite on granodiorite-limestone contact; active 1928; adits 900, 175 ft.; shaft 125 ft. (caved), most ore for Coppertown furnace (1865-66) came from here; at 60-ft. depth lode was described as 14 ft. wide, 10% Cu. (Aubury, L. E. 05, p. 155; 08, p. 181; Averill, C. V. 28a, p. 280; 37, p. 136; Browne, J. R. 67, p. 153; Crawford, J. J. 94, p. 68; Diller, J. S. 08, p. 116; MacBoyle, E. 20a, p. 159.)
57	C	Robinson (Morning Star, Trenton)	E. C. Robinson, Oakland, Calif. (1939)	30, 31	23N	7E	MD	Gold mine; also silver, lead. (Averill, C. V. 37, p. 136.)
*58	C	Rocky Point	J. L. Williams, Paxton, Calif. (1925)	Approx.	27N	11E	MD	Gold mine; also silver.
59	B	Ruby (Williams and Stark)	O. B. Camp, Engelmine, Calif. (1936)	13	27N	10E	MD	Copper mine (bornite); also gold, silver; 200-ft. adit; other workings; one stope 35 ft. long, 75 ft. high; said to have produced $16,000, 1916-19; mill under construction in 1920; run by electricity; $500,000 spent in 1923. (Averill, C. V. 28a, p. 280; 37, p. 136; Logan, C. A. 21, p. 469.)
		Shaw: see Husselman and Shaw						
60	D	Shoofly	G. H. Goodhue, Quincy, Calif. (1936)	3, 4, 10 32, 33	25N 26N	9E 9E	MD MD	Copper mine; bornite in sheets and lenses over wide zone; adit 80 ft. (Aubury, L. E. 08, pp. 182-184; Averill, C. V. 37, p. 137; MacBoyle, E. 20a, pp. 62-63.)
*61	C	Sierra Range	Sierra Range Copper Co., Taylorsville, Calif. (1917)	Approx.	26N	10E	MD	Copper mine; also silver.
°62	D	Snowstorm	Feather River Copper Co., Phoenix, Ariz. (1936)	17, 18 19 20	27N	11E	MD	Copper mine; 1,200 ft. (1920) adit was to be extended 2,000 ft. to prospect formation near Engels-Superior No. 2 ore body; no ore at 1,200 ft. (Averill, C. V. 37, p. 137; Logan, C. A. 21, p. 469.)
*63	C	Standard group	McKelvey & Kerley, Genesee, Calif. (1929)	26			MD	Gold mine; also silver.
64	C	Standart	Indian Valley Mining Co., Seattle, Wash. (1940)	11, 12 14	26N	9E	MD	Gold mine; also silver. (Averill, C. V. 37, p. 137.)
*65	C	Starlight	Brossaid & Williams, Engelmine, Calif. (1923)	Approx.	27N	11E	MD	Copper mine; also silver.

PLUMAS COUNTY—Continued

Number	Class by production	Name of deposit	Name of owner or operator	Location				Remarks and references
				Sec.	T.	R.	B. & M.	
66	A	Superior: see also Engels	Engels Copper Mining Co., 364 Mills Bldg., San Francisco, Calif.	15, 16 17, 18 19, 20	27N	11E	MD	Copper mine; also gold, silver; located 1 mi. W. of Engels mine; apparently about 1/5 size of Engels; six veins with chalcopyrite, small amounts of pyrite, bornite, magnetite, tetrahedrite, galena, and sphalerite; in quartz monzonite cut by acid dikes; walls are extensively tourmalinized, in places epidotized; gangue is biotite and tourmaline. (Knopf, A. 35, pp. 241-245.)
		Telge: see Beardsley						
67	C	Trask and Coffer (Beetle, Moonlight)	C. L. Eaton (1937)	24, 25 19, 30	27N 27N	10E 11E	MD MD	Copper-gold mine; also silver; narrow veins in basic dike; 900-ft. adit; 100-ft. winze stoped to adit level; worked 1874; relocated 1906, worked 1916-20; small mill, 1918; electric power; 160 tons shipped, 10% Cu, 40 oz. Ag, $3 Au. (Averill, C. V. 28a, p. 280; 37, p. 137; Logan, C. A. 21, pp. 470-471; MacBoyle, E. 20a, p. 61.)
		Trenton: see Robinson						
68	D	U.S. Smelting, Refining, & Mining Co. (Lena)		6, 7 12	24N 24N	12E 11E	MD MD	Copper mine; idle many years; 200 acres patented; ore in bunches in 16-20 ft. quartz vein; adits 1,200 ft., 260 ft.; winze 85 ft. (Averill, C. V. 28a, p. 280; 37, pp. 133, 137; Logan, C. A. 21, p. 468.)
69	D	Valentine	George H. Stephan et al., Quincy, Calif. (1936)	30	22N	13E	MD	(Averill, C. V. 27, p. 137; MacBoyle, E. 20a, p. 168.)
70	A	Walker	Walker Mining Co., 818 Kearns Bldg., Salt Lake City, Utah (1943)	5, 6} 7, 8} 29, 30} 31, 32}	24N 25N	12E 12E	MD MD	Copper mine; chalcopyrite in schist (andalusite-garnet rock and cordierite hornfels); minor pyrrhotite and cubanite, locally much magnetite; pyrite rare; gangue is quartz, and a little barite; walls tourmalinized. (Averill, C. V. 37, p. 138; Knopf, A. 35, pp. 241-245; Mining World 42, p. 39; Neale, W. G. 26, pp. 554-556; Rand, L. H. 31, pp. 685-686.)
		Walker Consolidated: see Consolidated Gold & Metals Co.						
		Ward: see Gruss						
*71	C	White	W. T. White, Johnsville, Calif. (1912)	Approx.	22N	11E	MD	Gold mine; also silver.
72	D	Williams		6	25N	12E	MD	Large mineralized outcrop. (Aubury, L. E. 08, pp. 184-185; MacBoyle, E. 20a, p. 64.)
		Williams & Stark: see Ruby						
*73	C	W.O.P.	W.O.P. Co., Chilcoot, Calif. (1915)	Approx.	22N	16E	MD	Gold mine; also silver.

* Not shown on map because of lack of definite location.
° Not shown on map because of crowded condition.

RIVERSIDE COUNTY

Number	Class by production	Name of deposit	Name of owner or operator	Location				Remarks and references
				Sec.	T.	R.	B. & M.	
1	C	Alice	Reliance Cons. Gold Mines, Inc., E. P. Warner, pres., Vidal, Calif. (1937)	25, 36	1S	23E	SB	Gold mine; defunct in 1942; 4½ mi. S. of Vidal, Bendigo district; adits 800, 200 ft.; winze 100 ft.; on 4-6 ft. vein on schist-limestone contact; 90 tons shipped, 1914. (Tucker, W. B. 29a, p. 472; 34, pp. 320-321; 45, p. 127; Zimmerman, J. 37, p. 794.)
2	D	Anderson	Anderson & Associates, Indio, Calif. (1945)	9	2S	12E	SB	Copper claim; adit 100 ft.; shaft 80 ft.; on NW-trending vein 2-6 ft. wide; quartz with malachite and azurite in granite and schist. (Aubury, L. E. 05, p. 257; 08, p. 342; Merrill, F. J. H. 19, pp. 524-525; Tucker, W. B. 29a, p. 469; 45, p. 124.)
		Arioa: see Lum Grey						
*3	C	Asset Realization Mining Co.	Asset Realization Mining Co., Blythe, Calif. (1914)	Approx.	6S	21E	SB	Gold mine; also silver.
		Badger State: see Crescent copper group						
*4	C	Baker Copper Co.	Baker Copper Co., Vidal, Calif. (1917)	Approx.	6S	23E	SB	Copper mine; also silver.
*5	C	Bendigo	Bendigo Mining Co., Vidal, Calif. (1916)	Approx.	2S	23E	SB	Copper mine; also silver, gold.
6	D	Big Horn group		2, 3 27,34,35	4S 3S	20E 20E	SB SB	Copper mine; chrysocolla, malachite in quartz veins in porphyry belt 300 ft. wide; shafts 50, 25, 25, and 22 ft. (Tucker, W. B. 29a, pp. 469-470; 45, p. 124.)
7	B	Black Eagle	Imperial Metals, Inc., Los Angeles, Calif. (1945)	25	3S	13E	SB	Copper-gold-lead-silver mine; shaft 400 ft., intersected by adit 80 ft. from collar; drifts on levels at 100, 200, 300 ft.; vein 4-10 ft. wide, on diorite-quartzite contact; has produced about 100,000 lbs. of copper, production in lead and gold more important; active 1925-26, 1938-41. (Tucker, W. B. 24, pp. 193-194; 29a, pp. 474-475; 38, p. 14; 40, p. 47.)
		Brannigan: see Brooklyn-Los Angeles						
8	C	Brooklyn-Los Angeles (Brannigan)	Brooklyn Mining Co., Highland, Calif. (1941)	1	2S	12E	SB	Gold mine; also silver, lead; has been reported to be in San Bernardino County. (Tucker, W. B. 31, pp. 289-290; 34, p. 321.)
*9	C	Butte	P. Cochet & Wiley Bros., Blythe, Calif. (1941)	Approx.	6S	21E	SB	Gold mine; also silver.
		Calzona: see Mountaineer						

RIVERSIDE COUNTY—Continued

Number	Class by production	Name of deposit	Name of owner or operator	Location Sec.	T.	R.	B. & M.	Remarks and references
10	C	Carolina 1, 2, 3, 4	A. Beven, Escondido, Calif. (1938)	19?	2S	20E	SB	Gold mine; also silver.
11	C	Chuckawalla	Chuckawalla Development Co., Los Angeles (1935)	31, 32	6S	16E	SB	Gold mine; also silver, lead. (Tucker, W. B. 45, p. 129.)
*12	C	Continental Mining & Development Co.	Continental Mining & Development Co., Blythe, Calif. (1916)	Approx.	6S	21E	SB	Copper mine.
13	C	Crescent copper group (Badger State, Badger State group, Eagle Nest)	Coke & Combs, Yermo, Calif. (1945)	29, 30	4S	20E	SB	Copper mine; said to have favorable possibilities; 3000 ft. of workings on 4-8 ft. zone; in schist with malachite, azurite, cuprite, chalcocite in quartz-calcite veins. (Aubury, L. E. 05, p. 258; 08, p. 342; Merrill, F. J. H. 19, pp. 525-526; Rand, L. H. 31, p. 665; Tucker, W. B. 29a, p. 470; 45, p. 124.)
14	C	Desert Rest	Desert Rest Mines, Inc., Rice, Calif. (1933)	19?	2S	20E	SB	Gold mine; also silver.
*15	C	Diane	R. A. Theobold, Los Angeles, Calif. (1939)	Approx.	2S	12E	SB	Gold mine; also silver.
		Eagle Nest: see Crescent						
16	D	Electric Copper and Gold	Mrs. C. Carter, Elsinore, Calif. (1945)	25	6S	4W	SB	Copper mine (cuprite, chrysocolla, chalcopyrite); also pyrite; at contact of granite and schist; 60-ft. shaft, 20-ft. crosscut; drifts on 10-ft. mineralized zone. (Tucker, W. B. 29a, p. 470; 45, p. 124.)
17	D	Fluor Spar group	Favret & Raines, Blythe, Calif. (1945)	4	3S	18E	SB	Copper prospect (malachite, azurite); also fluorspar; at contact of porphyry and monzonite; shallow cuts. (Aubury, L. E. 05, p. 258; 08, p. 343; Merrill, F. J. H. 19, p. 526; Tucker, W. B. 29a, p. 470; 45, p. 126.)
*18	C	Galena No. 1	F. Speiss, Corona, Calif. (1939)	Approx.	8S	4E	SB	Copper mine; also silver.
19	C	Gold Crown claim	Gold Crown Mining Co., Los Angeles, Calif. (1937)	15, 16	2S	12E	SB	Gold mine; also silver. (Tucker, W. B. 29a, p. 478.)
20	C	Gold Dollar	J. H. Ware, Kingman, Arizona (1945)	35, 36	1S	23E	SB	Gold mine; also silver; adits 430, 65 ft.; drifts 250 ft.; winze 50 ft; on series of parallel veins 1-10 ft. wide; one ore shoot 150 ft. long; 150 tons shipped. (Tucker, W. B. 29a, p. 479; 45, p. 131.)
*21	C	Golden Key	E. Swanson, Blythe, Calif. (1937)	Approx.	6S	16E	SB	Gold mine; also lead, silver.

		Hamilton: see Randolph and Hamilton						
22	D	Homestake		10	4S	18E	SB	Shallow shafts and cuts. (Aubury, L. E. 05, p. 257; 08, pp. 341-342; Tucker, W. B. 29, pp. 470-471.)
*23	C	Ironwood	H. Robbins, Riverside, Calif. (1916)					Gold mine?
		Jackknife: see Morning Star						
24	D	Lion's Den	Favret & Raines, Blythe, Calif. (1945)	17, 18	4S	22E	SB	Copper prospect (malachite and azurite at contact of diorite and limestone). (Tucker, W. B. 45, p. 126.)
		Los Angeles: see Brooklyn-Los Angeles						
25	C	Louise	E. Bethurum, Perris, Calif. (1939)	17, 18	2S	12E	SB	Gold mine; also lead, silver. (Tucker, W. B. 29a, pp. 483-484; 45, p. 35.)
*26	C	Lucky Jim	Lucky Jim Mine, Blythe, Calif. (1929)	Approx.	5S	20E	SB	Copper mine; also silver.
*27	C	Lum Grey (Arica, Priest)	F. E. Dennewiler, Blythe, Calif. (1945)	Approx.	2S	20E	SB	Gold mine; also silver. (Tucker, W. B. 45, p. 138.)
*28	C	MacLeish	M. MacLeish, Blythe, Calif. (1918)	Approx.	5S	20E	SB	Gold mine; also lead, silver.
*29	C	McConkey	McConkey Mine, Twenty-nine Palms, Calif. (1941)	Approx.	2S	12E	SB	Lead-silver mine; also gold.
*30	C	McCoy Mountain	J. M. Herndon, Blythe, Calif. (1909)	Approx.	5S	20E	SB	Copper mine; also silver, gold.
*31	C	Mecca claim	Mecca Mines, Inc., Los Angeles, Calif. (1927)					Copper mine; also lead, silver, gold.
32	C	Mission	Mission Gold Mining Co., Mecca, Calif. (1942)	5	3S	12E	SB	Gold mine; also silver. (Tucker, W. B. 40, p. 51; 45, p. 139.)
*33	C	Mojave	J. C. Brown, Rice, Calif. (1935)					Gold mine; also silver.
34	B	Morning Star (Jackknife)	Morning Star Mining Co., Los Angeles, Calif. (1945)	31	1S	24E	SB	Gold mine; adjoins Mountaineer on the south. (Tucker, W. B. 45, p. 139, pl. 35.)
35	D	Mountain King		23	4S	20E	SB	Copper mine; shaft 50 ft.; open cuts. (Aubury, L. E. 05, p. 257; 08, p. 342; Merrill, F. J. H. 19, p. 525; Tucker, W. B. 29a, p. 471; 45, pl. 35.)
36	B?	Mountaineer (Calzona)	Mountaineer Mining Co., Los Angeles, Calif. (1935)	31	1S	24E	SB	Gold mine; also silver. (Tucker, W. B. 34, p. 321; 45. p. 140.)

RIVERSIDE COUNTY—Continued

Number	Class by production	Name of deposit	Name of owner or operator	Location: Sec.	T.	R.	B. & M.	Remarks and references
37	D	Nancy		28?	3S	13E	SB	Copper prospect (malachite, azurite, chalcopyrite vein on diorite-quartz monzonite contact); shaft 130 ft.; drifts on 100-ft. level on 4-ft. vein. (Tucker, W. B. 29a, p. 471; 45, p. 126.)
38	D	Nicolite		32	1S	24E	SB	Gold mine. (Tucker, W. B. 45, pl. 35.)
*39	C	Nickel Plate	E. B. Trent, Dreman, Calif. (1931)					Gold mine; also silver.
*40	D	Orphan Boy			4S	18E	SB	(Aubury, L. E. 05, p. 256; 08, p. 341; Merrill, F. J. H. 19, p. 526.)
*41	C	Overton	Overton Mining Co. (1924)					Gold mine; also silver.
42	D	Palen Mountain		22	5S	18E	SB	Iron mine (magnetite); shallow cuts. (Aubury, L. E. 05, p. 256; 08, p. 341; Tucker, W. B. 45, pl. 35.)
*43	C	Palisade	A. Villman, Blythe, Calif. (1919)	Approx.	5S	20E	SB	Lead-silver mine.
44	C?	Palisades group	G. Peterson, Elsinore, Calif. (1929)	4	6S	4W	SB	Lead-silver prospect. (Tucker, W. B. 29a, p. 491.)
		Priest: see Lum Grey						
		Pyster: see Thackery-Pyster						
45	C	Rainbow	J. Anderson, Palo Verde, Calif. (1945)	17, 18	8S	21E	SB	Gold mine; also silver. (Tucker, W. B. 45, p. 142.)
46	D	Randolph and Hamilton		7	2S	20E	SB	Shaft 21 ft. (Aubury, L. E. 05, p. 257; 08, p. 342; Merrill, F. J. H. 19, p. 525.)
47	C	Red Cloud	S & W Mine Development Co., Los Angeles, Calif. (1935)	5	7S	15E	SB	Gold-tungsten mine; also silver, lead. (Tucker, W. B. 40, p. 51; 45, pp. 141, 157.)
		Rosalia: see Santa Rosa						
48	C	St. John		32?	4S	20E	SB	Copper prospect; some sorted ore shipped; shaft 75 ft., on 6-ft. vein in schist. (Tucker, W. B. 29a, p. 471; 45, p. 126.)
49	C	Sanborn	J. Sanborn, Calzona, Calif. (1911)	36?	1S	23E	SB	Copper mine; also gold, silver.

50	C	Santa Rosa (Rosalia)	Hook Bros., Perris, Calif. (1915)	31	4S	4W	SB	Gold mine; also silver, lead. (Sampson, R. J. 35, p. 514.)
*51	C	Scott Lode No. 1	McMillan & Plummer, Blythe, Calif. (1934)	Approx.	5S	20E	SB	Copper mine; also lead, silver, gold.
*52	C	Smith	C. H. Smith, Mecca, Calif. (1937)					Gold mine; also silver.
*53	C	Spider Web No. 1	R. Barger, Cross Roads, Calif. (1939)	Approx.	4S	4W	SB	Copper mine; also gold.
54	C	Steece		6	2S	24E	SB	Gold mine. (Tucker, W. B. 45, pl. 35.)
*55	D?	Thackery-Pyster	F. A. Thackery, Carlsbad, Calif.; and J. Pyster, Coachella, Calif. (1944)		3S 3S	10E 11E	SB SB	Copper mine; narrow stringers and a few veins of chrysocolla, malachite, and minor cuprite; 12 pits along E-trending ridge of gneiss.
*56	D	Vulture Crag			5S	1W?	SB	Possibly in Orange County. (Aubury, L. E. 05, p. 258; 08, p. 343.)
*57	D	Watch Me			1S	22E	SB	

* Not shown on map because of lack of definite location.

SACRAMENTO COUNTY

Number	Class by production	Name of deposit	Name of owner or operator	Location				Remarks and references
				Sec.	T.	R.	B. & M.	
*1	C							Production recorded for 1901, 1933-34, 1936; principal producer was Natomas dredge on American River; a little lead also produced. (Dolbear, S. H. 45, pp. B84-B87.)

* Not shown on map because of lack of definite location.

SAN BENITO COUNTY

Number	Class by production	Name of deposit	Name of owner or operator	Location				Remarks and references
				Sec.	T.	R.	B. & M.	
1	C	Antelope	H. V. Underwood, Hollister, Calif. (1925)	4	15S	9E	MD	Copper mine; adit 450 ft.; incline 200 ft. on mineralized zone in slate. (Irelan, W. Jr. 88, p. 489; Laizure, C. McK 26, p. 231; Preston, E. B. 93b, p. 371.)
2	C	Copper Mountain	Copper Mountain Mining Co. (1925)	33, 34	16S	7E	MD	Copper mine; open cuts on copper stains in granite; (Bradley, W. W. 19, pp. 631-632; Laizure, C. McK 26, p. 233; Neale, W. G. 27, p. 460-461.)
3	D?			33	14S	10E	MD	Copper prospect. (Yates, R. G. 45, p. 21.)
4	D	Lewis & Clark claim (Lewis Creek)		2, 3, 4	19S	10E	MD	100-ft. adit on croppings in sandstone and serpentine. (Aubury, L. E. 05, p. 146; 08, p. 172.)
		Lewis Creek: see Lewis & Clark						

SAN BERNARDINO COUNTY

Number	Class by production	Name of deposit	Name of owner or operator	Location: Sec.	T.	R.	B. & M.	Remarks and references
*1	C		C. B. Reno, Barstow, Calif. (1942)	Approx.	8N	1W	SB	Lead-silver mine; also gold.
*2	C		J. Fellinger; Barstow, Calif. (1941)	Approx.	8N	2W	SB	Silver mine.
*3	C		Huckleberry & Dawson, Wheaton Springs, Calif. (1943)					Lead-silver mine; also gold.
*4	C		Hart & Bell, Ivanpah, Calif. (1941)	Approx.	15N	14E	SB	Zinc-silver mine.
*5	C		Universal Industries, Inc., Victorville, Calif. (1943)					Lead-silver mine.
*6	C		C. Stewart, Needles, Calif. (1943)	Approx.	8N	22E	SB	Gold mine; also silver.
*7	C		L. Pritt, Earp, Calif. (1941)	Approx.	1N	25E	SB	Copper mine; also gold.
*8	C		C. L. Dunbar, Earp, Calif. (1942)	Approx.	1N	25E	SB	Gold mine.
9	C	Allured	Allured Copper Mining Co., M. E. Allured, Jackson, Calif.	9	15N	14E	SB	Copper mine; copper carbonate and sulphide veins in limestone, near quartz monzonite contact; two shafts, 125 ft.; small production. (Newman, M. A. 22, p. 611; Tucker, W. B. 30, p. 205; 31, p. 265; 43b, p. 430.)
10	C	Alta (Riggs)	W. B. Turner, Long Beach, Calif. (1943)	6	16N	9E	SB	Lead-silver mine. (Tucker, W. B. 43b, p. 474.)
*11	C	Alta Crown	J. A. Sidler, Cima, Calif. (1912)	Approx.	15N	14E	SB	Copper mine; also silver, gold.
12	C	Alvord	C. M. Alvord (1926)	1, 2, 12	11N	3E	SB	Gold-lead mine; also silver. (Tucker, W. B. 40, p. 53; 43b, p. 438.)
13	C	Amazon	F. H. Cline, Oro Grande, Calif. (1930)	4, 11?	6N	4W	SB	Copper mine; limestone-diorite contact; shafts 265 ft; several adits; 300 tons sorted ore shipped. (Aubury, L. E. 05, p. 11; Cloudman, H. C. 19, p. 784; Crawford, J. J. 94, p. 69; 96, p. 60; Storms, W. H. 93, p. 363; Tucker, W. B. 30, p. 205; 31, p. 265.)
14	C	American	Pluth Estate, Daggett, Calif. (1940)	19	4N	11E	SB	Gold-silver mine; fractures in rhyolite. (Tucker, W. B. 40, p. 54; 43b, p. 440.)

SAN BERNARDINO COUNTY—Continued

Number	Class by production	Name of deposit	Name of owner or operator	Location Sec.	T.	R.	B. & M.	Remarks and references
15	C	American Eagle	John Jarvis, Parker, Ariz. (1943); Eagle Sulphide Copper Co., 940 Citizens Nat'l. Bank Bldg., Los Angeles, Calif. (1930)	32	3N	24E	SB	Copper mine, said to be large; low-grade siliceous ore (chalcopyrite and pyrite) in schist; 130-ft. shaft; drifts; 3 years prior to 1918 production was 571 tons of 10.7% Cu, netting $15,230; reserves 90,000 tons of 3.8% Cu. (Aubury, L. E. 08, p. 337; Cloudman, H. C. 19, p. 784; Rand, L. H. 31, p. 544; Tucker, W. B. 30, p. 206; 31, p. 266; 43b, p. 430.)
*16	C	Anchor (New Trail?)	New Trail Mining Co., J. F. Kent, pres., Box 867, Riverside, Calif. (1930)		13N	14E	SB	Production recorded for 1928-29. (Symons, H. H. 30, p. 172; 31, p. 172.)
*17	C	April Fool	B. Trueman (1922)					Gold-lead mine? Also silver, zinc.
		Arlington: see Sante Fe						
*18	C	Arnold-Edward	E. Arnold, Vidal, Calif. (1915)	Approx.	2N	23E	SB	Gold mine; also silver.
*19	C	Avaitai	H. Roberts, Calzona, Calif. (1911)					Gold mine? Also silver.
20	C	Avawatz Crown	Avawatz Cons. Mines Co., Los Angeles, Calif. (1943)	26	16N	6E	SB	Lead-silver mine; also gold. (Tucker, W. B. 43b, p. 474.)
21	C	Aviation	B. E. DelMar, Los Angeles, Calif. (1935)	8	3N	2E	SB	Lead-silver mine? Also gold.
		B & B group: see Pilot						
22	B	Bagdad-Chase (Pacific, Barstow Mill)	J. H. Hobbs, Glendora, Calif. (1943)	8	6N	8E	SB	Copper-gold mine; also silver, lead; copper oxides in siliceous igneous breccia on contact of monzonite and rhyolite; production 1902-44 not continuous; tailings reworked at Barstow Mill. (Tucker, W. B. 43b, p. 440; 43a, p. 126.)
		Baltic: see Calico-Odessa						
		Bank Roll: see Green Gold						
*23	C	Bannock & Bertha	Pooser & Wishard, Needles, Calif. (1937)	Approx.	9N	20E	SB	Gold mine? Also silver.
		Barnett: see Lost Mormon						
24	C	Barrett		18	12N	15E	SB	Gold mine. (Tucker, W. B. 31, p. 287.)
		Barstow Mill: see Bagdad-Chase						

25	B	Bell Gilroy (Belle McGilroy)	H. Williams, Randsburg, Calif. (1943)	9	10N	14E	SB	Lead-silver mine. (Tucker, W. B. 43b, p. 475.)
*26	C	Best	J. M. Best, Silver Lake, Calif. (1913)	Approx.	15N	9E	SB	Silver mine?
27	C	Big Butte (Copper Gulch)	E. F. Russell, Needles, Calif. (1943)	28	9N	22E	SB	Copper mine; small production in 1913; 125-ft. shaft; adits. (Cloudman, H. E. 19, p. 785; Tucker, W. B. 30, p. 206; 31, p. 266; 43b, p. 432.)
*28	C	Big Cherokee	J. W. R. Hillard, Beatty, Nevada (1939)					Lead-silver mine.
29	C	Big Four (Red Bridge)	W. B. Redfield estate, Goldstone, Calif. (1943)	9	14N	1E	SB	Gold mine; also lead, silver. (Tucker, W. B. 40, p. 57; 43b, p. 441.)
30	C	Big Horn (Mabel-Contention)	Thomson & Johnson, Baker, Calif. (1941)	20	9N	14E	SB	Gold mine; also lead, silver; veins on walls of andesite dikes in quartz monzonite. (Tucker, W. B. 40, p. 58; 43b, p. 441.)
		Big Ten: see Ozark						
*31	C	Birnbach	A. Birnbach, Calzona, Calif. (1911)	Approx.	2N	25E	SB	Copper mine.
		Bismark: see Calico-Odessa						
32	D	Blacet	Wesley Blacet, Pomona, Calif. (1943)	3, 4	4N	5E	SB	
33	D	Black Diamond	J. Scheerer estate, Victorville, Calif. (1930)	3	6N	4W	SB	Copper mine; vein at granite dike contact; 150-ft. shaft; cuts. (Cloudman, H. E. 19, p. 785; Tucker, W. B. 30, p. 206; 31, p. 266.)
		Black Hawk: see Sante Fe						
*34	C	Black Metal	W. H. Ballinger, Glendale, Calif. (1941)		1N	24E	SB	Copper mine; chrysocolla, also horn silver; produced 1941-42; high-grade ore in early days; shaft 30 ft.; drift 80 ft.; adits 75 and 40 ft. (Crawford, J. J. 94, p. 376; 96, p. 606; Tucker, W. B. 30, p. 206; 31, p. 266.)
35	D	Black Mountain	Jennie M. Watts, Dan T. Watts, 1119 Knoll Drive, Monterey Park, Calif.	36	10N	21E	SB	Copper mine. (Cloudman, H. E. 19, p. 785; Tucker, W. B. 30, p. 206; 31, p. 266.)
36	C?	Black Mountain	Watts & Watts, Monterey Park, Calif. (1943)	19	6N	7W	SB	Copper mine; malachite, chalcopyrite, and bornite on contact between granite and limestone; shallow shafts on parallel veins 1 to 2 ft. wide in gneiss. (Sampson, R. J. 37, p. 175; Tucker, W. B. 43b, p. 430; 27, p. 289.)
*37	C	Blue Buzzard	Whitney & Bauer, Nipton Calif. (1940)					Lead-silver mine.
*38	C	Blue Jacket (Hermit)			6N	4W	SB	Silver-copper mine; production recorded in 1888; relocated as Hermit in 1910. (Cloudman, H. E. 19, p. 787; Crawford, J. J. 96, p. 320; Irelan, W. 88, p. 500; Tucker, W. B. 31, p. 273.)

SAN BERNARDINO COUNTY—Continued

Number	Class by production	Name of deposit	Name of owner or operator	Location				Remarks and references
				Sec.	T.	R.	B. & M.	
*39	C	Blue Moon	T. J. Hammond, Ivanpah, Calif. (1940)	Approx.	16N	14E	SB	Lead-silver mine.
40	C	Bonanza King	Bonanza King Mines, Fenner, Calif. (1936)	31	10N	14E	SB	Silver-lead mine; also gold. (Tucker, W. B. 31, p. 342; 43b, p. 475.)
*41	C	Bowman	F. A. Bowman, Calzona, Calif. (1911)	Approx.	2N	25E	SB	Silver-gold mine?
42	C	Brannigan	Best, Herrod, & Thompson, Baker, Calif. (1940)	35	13N	10E	SB	Gold mine; also silver. (Tucker, W. B. 31, p. 289.)
		Brannigan: see Brooklyn-Los Angeles under Riverside County						
43	C	Break of Day (Three States)		21	15N	7E	SB	Copper mine; small production; chalcopyrite on contact of diorite dike and limestone. (Cloudman, H. E. 19, p. 791; Tucker, W. B. 30, p. 220; 31, p. 280.)
*44	C	Brice	J. S. Brice, Needles, Calif. (1908)	Approx.	9N	22E	SB	Gold mine; also silver.
45	C	Brilliant	H. Stevenson, Los Angeles, Calif. (1944)	24	7N	1E	SB	Gold mine; also silver; may be shaft of Ord Mountain mine. (Tucker, W. B. 40a, p. 239.)
*46	C	Bronze	H. C. Ferris, Ivanpah, Calif. (1935)	Approx.	15N	13E	SB	Lead-silver mine; also gold.
		Brooklyn—Los Angeles: see under Riverside County						
*47	C	Bruce	B. McCormick, Yermo, Calif. (1907)	Approx.	8N	2E	SB	Copper mine.
*48	C	Budget	F. E. McCaughey, Nipton, Calif. (1939)	Approx.	16N	13E	SB	Lead-silver mine; also gold.
49	C	Bullion	J. Johnson, Cima, Calif. (1943)	3	15N	14E	SB	Lead-silver mine; also gold. (Tucker, W. B. 31, p. 343; 43b, p. 475.)
50	D	Bumper group	E. H. and H. A. Norton, Needles, Calif. (1930)	30	7N	23E	SB	Copper mine, malachite, azurite; also zinc (franklinite, zincite); shaft 22 ft.; drift 65 ft. (Cloudman, H. E. 19, p. 785; Tucker, W. B. 30, p. 206; 31, p. 266.)
51	C	Burcham (Total Wreck)	R. L. Burcham, Alhambra, Calif. (1943)	15, 16 21	10N	1E	SB	Silver-lead mine; also gold. (Erwin, H. D. 40, pp. 302-303; Tucker, W. B. 43b, p. 475.)

52	C	Calarivada	Colosseum Mines Corp. (1930)	11	18N	13E	SB	Copper mine; vein 2 to 4 ft. wide, in fractured bedding planes of limestone; shaft 200 ft.; drifts 400 ft. (Tucker, W. B. 24, p. 93; 30, p. 207; 31, p. 267.)
53	C	Calico-Odessa (Baltic, Bismark, Garfield, Odessa, Thunderer)	Mrs. J. R. Lane, Yermo, Calif. (1943)	10, 11 14, 15 23	10N	1E	SB	Silver-lead mine (cerargyrite, embolite); also gold and copper (chrysocolla); formerly separate mines; now a unit. (Erwin, H. D. 40, p. 301; Tucker, W. B. 43b, p. 477.)
54	C	California Comstock	California Comstock Gold Mines, Ltd., San Bernardino, Calif. (1935)	16	11N	18E	SB	Lead-silver mine; also gold.
		California Gold Copper Co.: see Vontrigger						
		California Rand: see Kelly						
*56	D	Calumet and California			16N	9E	SB	
		Calzona: see Mountaineer, in Riverside County						
*58	C	Cambria	Walker Bros. Bank, Salt Lake City, Utah (1908)	Approx.	16N	14E	SB	Gold mine? Also silver. (Cloudman, H. E. 19, p. 808.)
59	C	Camp Castle (Great Gold Belt mine)	Bower, Wooten & Etter, Mojave, Calif. (1941)	26	7N	13E	SB	Gold mine; also silver. (Tucker, W. B. 30, p. 230.)
*60	C	Camp Vera group			30S	46E	MD	Copper mine; widespread mineralization as streaks and narrow veins in 50 to 500 ft. zone; 20 shafts, 2 to 10 ft.; shaft 100 ft. (Aubury, L. E. 05, p. 252; Cloudman, H. E. 19, p. 785; Tucker, W. B. 30, p. 207; 31, p. 267.)
61	C	Carbonate	California Portland Cement Co., Oro Grande, Calif. (1940)	17	6N	4W	SB	Lead-silver mine; also gold.
62	C	Carbonate King (Crystal Cave)	P. R. Ressler, Nipton, Calif. (1942)	32	16N	14E	SB	Zinc-lead-silver mine; also gold; fractures in limestone. (Tucker, W. B. 31, p. 347.)
63	C	Carlyle	Carlyle Mining Corp., Twenty-nine Palms, Calif. (1938)	11	1S	12E	SB	Gold mine; silver-lead, copper also; veins in fissure in diorite and granodiorite. (Tucker, W. B. 40, p. 61; 43b, p. 444.)
		Chambers: see Silver Rule						
		Chase: see Bagdad-Chase						
*64	C	Chouse	F. Chouse, Needles, Calif. (1913)	Approx.	9N	22E	SB	Gold mine; also silver.
*65	C	Cima	Cima Commercial Trust Co., San Francisco, Calif. (1920)	Approx.	15N	13E	SB	Gold mine; also silver.
*66	C	Clark	I. W. Clark, Vidal, Calif. (1911)	Approx.	2N	23E	SB	Gold mine.

SAN BERNARDINO COUNTY—Continued

Number	Class by production	Name of deposit	Name of owner or operator	Location Sec.	T.	R.	B. & M.	Remarks and references
67	D	Claw Hammer group	J. Youngreen estate, Los Angeles, Calif. (1940)	9, 10	8N	1E	SB	Copper-gold mine; copper oxides in 4 to 10 ft. fracture system in quartz monzonite; 30-ft. shaft. (Tucker, W. B. 30, p. 207; 31, p. 267; 40a, p 234.)
68	C	Colosseum	Colosseum Mining & Smelting Corp., Hollywood, Calif. (1943)	10, 14	17N	13E	SB	Copper-gold mine; also silver, lead; pyrite and chalcopyrite on fractures in rhyolite plug. (Tucker, W. B. 43b, p. 446; 43a, p. 128.)
*69	C	Columbia	Eau Claire Ore Co., Kelso, Calif. (1938)	Approx.	10N	12E	SB	Silver-lead mine; also gold.
		Columbia: see Macedonia						
*70	C	Concha	L. Concha, Victorville, Calif. (1911)	Approx.	5N	4W	SB	Gold mine? Also lead.
71	D	Condor group	Elmo Parker, c/o Cronise Gas Station, via Baker, Calif. (1943)	23	12N	5E	SB	
72	C	Confidence		5	11N	14E	SB	Copper mine (chalcopyrite); tungsten (wolframite); gold; and pyrite; veinlets (in pegmatite?) at contact of granite and porphyry; 100-ft. shaft; other shallow workings. (Jenkins, O. P. 42, p. 351; Tucker, W. B. 21, p. 340; 30, p. 209; 31, p. 269.)
*73	C	Cooke & Dudley	R. A. Dudley, Needles, Calif. (1918)					Gold mine; also silver.
74	C	Copper Basin	Frank Ewing, Charles L. Lunbar, Parker, Ariz. (1944)	3, 4	2N	26E	SB	Copper mine (carbonates, oxides, sulphides); two mineralized zones in quartz porphyry, below 100 ft.; shafts 100, 80 ft.; strike N, dip 45° E.; produced 1930, 1943-44. (Newman, M. A. 22, p. 308; Tucker, W. B. 30, pp. 207-208; 31, p. 267; 43b, p. 431.)
75	C	Copper Bell group	Humphrey & Bowman, Parker, Ariz. (1913)	10	2N	25E	SB	Copper mine; quartz veins in granite; produced 1911, 1913. (Tucker, W. B. 21, p. 339; 30, p. 209; 31, pp. 267-268.)
*76	C	Copper Buttes	L. Larrian, Los Angeles, Calif. (1930)					Copper mine? Also gold, silver.
77	C	Copper Chief	Copper Chief Mining Co., Goffs, Calif. (1930)	16?	10N	18E	SB	Copper mine? Also gold, silver.
°78	D	Copper Commander	Mike Conway (at Copper World mine)	1	16N	13E	SB	Copper mine; ore on limestone-porphyry contact; 140-ft. adit; adjoins Copper World on northwest. (Tucker W. B. 24, p. 93; 30, p. 209; 31, p. 269; 43b, p. 433.)

		Copper Gulch: see Big Butte						
79	C	Copper King	J. Nelson, Cima, Calif. (1909)	25	15N	13E	SB	Copper mine; also silver. (Cloudman, H. E. 19, p. 785.)
80	D	Copper Mountain	----------	12	6N	4W	SB	Hanging wall limestone; several veins; developed 1874; shafts 200, 60, 40, 30 ft.; drifts 93 ft. (Aubury, L. E. 05, pp. 251-252; 08, pp. 333-334.)
*81	C?	Copper Queen	Colossus Copper Co., Barnwell, Calif. (1944)	Approx.	14N	16E	SB	Copper-tungsten-zinc deposit; vein over 10 ft. wide at one place.
82	C	Copper Strand (Independence)	Haney & Lee, Barstow, Calif. (1943)	9	6N	3E	SB	Copper mine (azurite, malachite, chalcopyrite); also pyrite; on contact of limestone and porphyry. (Tucker, W. B. 43b, p. 432.)
83	A	Copper World (Ivanpah-Old Ivanpah Copper)	Ivanpah Copper Co., Dr. L. D. Godshall, vice-pres. and mgr., Los Angeles, Calif. (1942)	6	16N	13E	SB	Copper mine; also silver, gold, lead; chalcopyrite at contact of limestone and porphyry; produced 1906-08, 1916-20, 1944. (Aubury, L. E. 08, p. 330; Cloudman, H. E. 19, p. 787; Tucker, W. B. 30, p. 214; 31, p. 269; 43b, p. 432.)
84	C	Coyote	C. O. Mittendorf, Randsburg, Calif. (1944)	6	30S	41E	MD	Silver mine; also gold. (Tucker, W. B. 30, p. 275.)
		Creole: see Crystal						
85	C	Crystal (Creole)	Simpson, Ploof, Erickson, & Mc-Spaden, San Bernardino, Calif. (1935)	22	4N	6E	SB	Copper mine.
		Crystal Cave: see Carbonate King						
86	C?	Crystal Cones No. 4	L. D. Ressler, Nipton, Calif. (1942)	4	15N	14E	SB	Zinc mine with copper.
*87	C	Cuprum	O'Meara & Lynch, Manville, Calif. (1905)	--------	--------	--------	--------	Copper mine.
88	C	D. and W. (Dayton and Wilber)	D. & W. Mining Co., Los Angeles, Calif. (1930)	6	2N	24E	SB	Copper mine (malachite, azurite); also silver, gold; in quartz porphyry dike in diorite; shaft 750 ft.; workings, 5,000 ft.; little production; adjoins American Eagle. (Aubury, L. E. 08, p. 337; Cloudman, H. E. 19, p. 786; Tucker, W. B. 30, p. 210; 31, p. 269.)
*89	C	Davis & Maxfield	Davis & Maxfield, Hallock, Calif. (1918)	--------	--------	--------	--------	Lead-silver mine.
		Dayton & Wilber: see D. & W.						
*90	C	Delape	Delape, Needles, Calif. (1909)	Approx.	8N	22E	SB	Copper mine?
*91	C	Del Oro	H. B. Snyder, Los Angeles, Calif. (1940)	--------	--------	--------	--------	Lead-silver mine; also gold;

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Number	Class by production	Name of deposit	Name of owner or operator	Location: Sec.	Location: T.	Location: R.	Location: B. & M.	Remarks and references
92	C	Desert Butte group	Parks & Crowley, Barstow, Calif. (1930)	16	3N	16E	SB	Copper mine; also zinc, lead; 40 tons complex ore shipped to Selby in 1941; adit, drift, 325 ft. (Cloudman, H. E. 19, p. 786; Tucker, W. B. 30, p. 210; 31, pp. 269-271.)
*93	C	Desert Queen		Approx.	19N	8E	SB	Copper mine; shipments reported. (Tucker, W. B. 31, p. 271.)
94	C?	Dewey		1	16N	13E	SB	Copper mine (oxides and chalcopyrite); in diorite porphyry. (Tucker, W. B. 43b, p. 433.)
*95	C	Dixie Extension No. 1	Dempsey & Martin, Barstow, Calif. (1942)	Approx.	8N	2W	SB	Silver-copper mine; also gold.
*96	C	Doran	A. L. Doran, Silver Lake, Calif. (1911)	Approx.	15N	9E	SB	Lead-copper mine.
97	C	Dull Pick	Russell & Brown, Ludlow, Calif. (1941)	12	6N	7E	SB	Gold mine; also silver. (Tucker, W. B. 40a, p. 235.)
*98	C	Dusty	A. T. Cornwall, Santa Barbara, Calif. (1935)	Approx.	29S	42E	MD	Gold mine; also silver.
*99	C	Dutch Silver claim	C. C. Townsend, Cima, Calif. (1928)					Lead-silver mine.
*100	C	D. V.	C. M. Alvord (1926)	Approx.	15N	14E	SB	Lead-silver mine; also gold.
*101	C	D. W. Earle	Earle & Co., Daggett, Calif. (1910)	Approx.	8N	1E	SB	Gold mine; also silver.
*102	C	Eagle	W. R. Collier (1935)	Approx.	2N	23E	SB	Gold mine; also silver.
*103	C	Eaton	C. J. Eaton, Goffs, Calif. (1913)	Approx.	9N	18E	SB	Gold mine; also silver.
*104	C	Elsie	Mrs. C. L. Miles (1940)	Approx.	3N	23E	SB	Gold mine; also silver.
105	C	Emerson	S. L. Emerson, Hodge, Calif. (1937)	9	4N	6E	SB	Gold mine; also silver, lead. (Tucker, W. B. 31, p. 294.)
106	B	Emperor	Ivanpah Copper Co., Nipton, Calif. (1919)	30	17N	13E	SB	Copper-lead-silver mine; also gold; adits 187, 150 ft.; winze 55 ft.; granite-limestone contact; ore shipped, 5% Cu, 11% Pb, 11oz. Ag. (Tucker, W. B. 21, p. 340; 31, p. 271.)

*107	C	Erisman	J. F. Erisman, Bakersfield, Calif. (1928)					Lead-silver mine; also gold.
*108	C	Eureka	Eureka Copper Co., Victorville, Calif. (1905)	Approx.	5N	4W	SB	Copper mine.
*109	C	Excelsior	Moore & Nelson, Manville, Calif. (1903)					Gold mine; also silver.
*110	B	Express	C. A. Housel, Cima, Calif. (1918)	Approx.	15N	13E	SB	Copper-gold mine; also silver.
*111	C	Fairbanks	D. A. Gardner, Leastalk, Calif. (1912)					Silver mine.
*112	C	Flee	W. M. Flee, Cima, Calif. (1918)	Approx.	15N	13E	SB	Silver mine.
		Foster: see Glory						
113	C	Francis	Francis Copper Mining Co., C. Colcock Jones, pres., 102 S. Occidental Blvd., Los Angeles, Calif. (1943)	7	11N	14E	SB	Copper mine; also lead, zinc; sulphide veins in quartz porphyry intrusions in schist; only production 307 tons in 1918: 2% Cu, 10oz. Ag; shafts, 140, 100, 40 ft.; workings, over 600 ft. (Tucker, W. B. 21, p. 341; 30, pp. 210-213; 31, pp. 271-272; 43b, p. 434.)
		Frank Royer: see Kelly						
		Fremont: see Mohawk						
114	C	Frisco claim	P. Thebadeau, Kelso, Calif. (1931)	18	11N	14E	SB	Gold mine; also silver. (Tucker, W. B. 31, p. 295.)
115	C	G. A. Fayle	G. A. Fayle, Cima, Calif. (1919)	12?	16N	13E	SB	Lead-silver mine; also gold.
*116	C	Garavanza	H. M. Barrfield, Leastalk, Calif. (1908)					Silver mine.
		Garfield: see Calico-Odessa						
117	C	Gateway	F. P. Rossiter, Pomona, Calif. (1935)	34	31S	42E	MD	Gold mine; also silver.
118	D	Giant Ledge	Earl Stuart Rhode, Los Angeles, Calif. (1943)	31, 32	14N	16E	SB	Copper mine (see also New York); vein quartz heavily stained with copper oxides; shafts 200, 60, three 30 ft.; drifts 48, 45 ft. (Aubury, L. E. 08, pp. 333-334; Cloudman, H. E. 19, p. 786; Tucker, W. B. 30, p. 213; 31, p. 272; 43b, p. 434.)
*119	C	Gibson	H. G. Gibson, Cima, Calif. (1913)	Approx.	15N	13E	SB	Gold mine; also silver.
*120	C	Gilchrist	W. L. Gilchrist, Vidal, Calif. (1911)	Approx.	2N	23E	SB	Gold mine; also silver.
*121	C	Gilson Small Quartz	McGee & Reysers, Vidal, Calif. (1912)		2N	23E	SB	Gold mine; also silver.

SAN BERNARDINO COUNTY—Continued

Number	Class by production	Name of deposit	Name of owner or operator	Location				Remarks and references
				Sec.	T.	R.	B. & M.	
*122	C	Gimmel	M. Gimmel, Vidal, Calif. (1915)	Approx.	2N	23E	SB	Gold mine; also silver.
123	C	Glory (Foster)	Foster Mines Co., Los Angeles, Calif. (1943)	14, 15	17N	11E	SB	Copper mine; parallel veins in prophyry and schist; shaft 125 ft., and others. (Tucker, W. B. 21, p. 341; 30, p. 210; 31, p. 271; 43b, p. 434.)
124	C	Gold Banner	W. M. Smith, Daggett, Calif. (1943)	13	7N	1E	SB	Copper-gold mine; copper carbonates, chalcopyrite, and bornite; in veins in andesite. (Gardner, D. L. 40, pl. 2; Tucker, W. B. 43b, p. 434.)
125	C	Gold Belt (McGinnis, Gold Peak)	E. L. Melville, Chula Vista, Calif. (1934)	30	7N	1E	SB	Gold mine; also silver. (Gardner, D. L. 40, pl. 2; Tucker, W. B. 31, p. 296; 40a, pp. 235-236; 43b, p. 448.)
*126	C	Gold Bronze	W. L. Marsh, Ivanpah, Calif. (1940)	Approx.	14N	16E	SB	Gold mine; also silver, lead; gold-quartz vein, heavily mineralized with pyrite. (Tucker, W. B. 30, p. 236.)
127	C	Gold Coin (Orange Blossom Extension)	Childers & Ormintrout, Victorville, Calif. (1934)	31, 32	8N	11E	SB	Copper mine; also gold, silver; shaft 715 ft.; workings 4,000 ft.; in 1913 gravity mill ran only a short time; quartz vein 4-20 ft. wide, with Cu, Au, Ag. (Cloudman, H. E. 19, pp. 788-789; Tucker, W. B. 30, p. 217; 31, p. 276.)
128	C	Gold Hill	E. A. Powell, Victorville, Calif. (1939)	17	2N	2E	SB	Gold mine; also silver, lead; veins in quartzite. (Tucker, W. B. 40, p. 66; 43b, p. 452.)
129	C	Gold Peak	R. H. Gilman, Pasadena, Calif. (1913)	30	6N	3E	SB	Gold mine; also lead, silver; veins in granite. (Gardner, D. L. 40, pl. 2.)
		Gold Peak: see Gold Belt						
130	C	Gold Standard	D. M. Campbell, Vidal, Calif. (1941)	32	7N	8E	SB	Gold mine; also silver; fractures in rhyolite. (Gardner, D. L. 40, pl. 2; Tucker, W. B. 40a, p. 236.)
*131	C	Gold Trail	C. L. Dunbar, Earp, Calif. (1940)	Approx.	2N	26E	SB	Copper mine.
*132	C	Golden Eagle	Bower & Moore, Amboy, Calif. (1941)	Approx.	6N	12E	SB	Lead-silver mine; also gold.
*133	C	Golden Wonder	H. Greene, Victorville, Calif. (1928)	Approx.	16N	14E	SB	Lead-silver mine; also gold.
*134	C	Grand Gorde and Troopers Tun.	C. A. Devins, Los Angeles, Calif. (1913)					Lead-silver mine; also gold.
*135	C	Grand Reef claim	R. A. Martin, Oatman, Calif. (1935)					Lead-silver mine; also gold.

		Great Gold Belt: see Camp Castle						
136	C	Green Gold (Bank Roll)	Wilton & Dunbar, Earp, Calif. (1939)	15	17N	13E	SB	Zinc-lead-copper mine; also gold. (Tucker, W. B. 30, p. 268.)
137	D	Halloran Springs (Toltec)	Kellogg & Welch, Los Angeles, Calif (1930)	17	15N	10E	SB	Copper-silver mine; oxidized copper minerals in shear zone; 30-ft. shaft; open cuts. (Tucker, W. B. 30, p. 213; 31, p. 273.)
*138	C	Hart	Hart Mining Co., Hart, Calif. (1909)	--------	--------	--------	--------	Gold mine; also silver.
*139	C	Hawkeye	J. W. Brunk, Vidal, Calif. (1916)	Approx.	1N	23E	SB	Gold mine; also silver.
*140	C	Hawley	W. E. Hawley, Vidal, Calif. (1916)	Approx.	1N	23E	SB	Copper mine.
*141	C	Henry	A. Henry, Cima, Calif. (1913)	Approx.	16N	13E	SB	Lead-silver mine; with gold.
		Henshaw: see Murray						
142	C	Hercules	R. Andrews, Bagdad, Calif. (1930)	18	7N	11E	SB	Copper mine; malachite and azurite veins in quartz porphyry; shaft 42 ft.; 1400 tons $7-ore shipped. (Cloudman, H. E. 19, pp. 786-787; Tucker, W. B. 30, p. 213; 31, p. 273.)
		Hermit: see Blue Jacket						
143	C	Hidden Hill	T. W. Crawford, Needles, Calif. (1914)	1	8N	13E	SB	Gold mine; also silver. (Tucker, W. B. 31, p. 301.)
144	D	Hidden Treasure	Moorehead & Chause, Goffs, Calif. (1930)	24	10N	20E	SB	Copper mine; ore at granite-schist contact; shaft, 160 ft. (Tucker, W. B. 21, p. 341; 31, p. 273.)
*145	C	Hillside	R. Cowan, Silver Lake, Calif. (1925)	Approx.	16N	10E	SB	Gold mine; also lead, silver. (Tucker, W. B. 31, p. 327.)
*146	C	Hinckley claim	J. T. Reed, Barstow, Calif. (1909)	Approx.	8N	1W	SB	Gold mine; also silver.
*147	C	Hoffman	C. J. McKay, Barstow, Calif. (1944)	Approx.	8N	1E	SB	Gold mine; also silver.
148	D	Home	Root & Luxon, Needles, Calif. (1930)	7	7N	11E	SB	Copper mine; quartz veins in granite; 75-ft. shaft. (Cloudman, H. E. 19, p. 787; Tucker, W. B. 30, p. 214; 31, p. 273.)
*149	C	Homestake	H. E. Briggs, Trona, Calif. (1940)	Approx.	25S	44E	MD	Lead-silver mine; also gold.
150	C	Hoosier and Missouri	Foglesong & Troutman, Barstow, Calif. (1930)	28	10N	3W	SB	Gold-silver-lead-copper mine; ore on granite-rhyolite contact; 90-ft. shaft; 300-ft. drift. (Cloudman, H. E. 19, p. 787; Tucker, W. B. 30, p. 214; 31, p. 273.)

SAN BERNARDINO COUNTY—Continued

Number	Class by production	Name of deposit	Name of owner or operator	Location				Remarks and references
				Sec.	T.	R.	B. & M.	
*151	C	Horn	Horn & Kelton, Parker, Ariz. (1917)					Copper mine.
*152	C	Hulsman	P. Hulsman, Vidal, Calif. (1937)	Approx.	3N	23E	SB	Gold mine; also silver.
*153	C	Hysters	J. S. Hysters, Silver Lake, Calif. (1912)	Approx.	15N	10E	SB	Gold mine; also silver.
154	C	Imperial Lode	W. W. Tucker, Los Angeles, Calif. (1937)	25, 35 36	7N	5E	SB	Silver mine; with gold and lead. (Tucker, W. B. 43b, p. 481.)
		Independence: see Copper Strand						
*155	C	Independence group	C. O. Hewins, Lucerne Valley, Calif. (1944)	Approx.	5N	2E	SB	Silver mine.
156	D	Indicator	Peter Hulsman, Vidal, Calif. (1943)	19	3N	23E	SB	
157	C	Iron Horse (Jack Rabbit)	T. Marteletti, Las Vegas, Nev. (1942)	35	16N	13E	SB	Lead-silver mine; also gold. (Tucker, W. B. 43a, p. 131.)
158	C	Islander	Parker Associates, Whittier, Calif. (1944)	4, 9	3N	26E	SB	Gold mine; also silver.
		Ivanpah: see Copper World						
159	D	Ivanpah Mammoth		14	15N	14E	SB	Copper mine. (Aubury, L. E. 08, p. 330; Cloudman, H. E. 19, p. 787; Tucker, W. B. 30, p. 214; 31, p. 273.)
*160	D	Jachon	R. M. Dillingham, Barstow, Calif. (1930)		12N	2E	SB	Copper-gold mine; oxidized copper minerals in fissures in granite; shaft 120 ft.; drift 60 ft. (Tucker, W. B. 30, p. 214; 31, p. 274.)
		Jack Rabbit: see Iron Horse						
*161	D	Jackass			11N	1W	SB	
*162	C	Jacknife group	Morgan & Bradley, Vidal, Calif. (1914)	Approx.	1N	23E	SB	Gold mine; also silver.
163	C	Jackpot	F. Labe, Los Angeles, Calif. (1941)	35	13N	12E	SB	Lead-silver mine; also gold.
*164	C	J. F. Morris	Co & Harrington, Cima, Calif. (1919)	Approx.	15N	13E	SB	Gold mine; also silver.

*165	C	Jim Tam	Courson & Martin, Randsburg, Calif. (1941)					Gold mine.
166	D	Josie K		31	9N	22E	SB	Copper mine; shallow shafts; rhyolite-granite contact. (Cloudman, H. E. 19, p. 787; Tucker, W. B. 30, p. 214; 31, p. 274.)
*167	C	Jost	J. H. Jost, Cima, Calif. (1918)					Silver mine.
168	C	Juanita group		34, 35, 36	29S	45E	MD	Copper mine (oxides); porphyry and limestone contact; 86 different shafts up to 80 ft. (Aubury, L. E. 05, p. 253; 08, p. 335; Cloudman, H. E. 19, p. 787; Tucker, W. B. 30, p. 214; 31, p. 274.)
*169	C	Kane Kelton & Horn	J. E. Kelton, Blythe Jct., Calif. (1915)	Approx.	1N	20E	SB	Silver mine; also gold.
170	C	Kelly (Frank Royer, Kelly Rand, California Rand)	F. Royer, Red Mountain, Calif. (1944)	6	30S	41E	MD	Silver mine; also gold, lead. (Symons, H. H. 38, p. 138; Tucker, W. B. 43b, p. 483.)
		Kelly Rand: see Kelly						
*171	C	Kent	G. A. Kent, Ivanpah, Calif. (1922)	Approx.	16N	14E	SB	Lead-silver mine; also gold.
*172	C	King claim	Earl & Co., Daggett, Calif. (1909)	Approx.	8N	1E	SB	Silver mine.
*173	C	Kramer Merc. & Supply Corp.	Kramer Merc. & Supply Corp., Kramer, Calif. (1913)	Approx.	10N	7W	SB	Silver mine.
174	D	L. and L.	L. & L. Mining Co., Riverside, Calif. (1940)	17	7N	3E	SB	Copper-gold mine; shaft, 50 ft.; adit, 470 ft.; quartz veins in porphyry with copper oxides, malachite, azurite; also bornite and chalcopyrite; with gold and silver values. (Cloudman, H. E. 19, p. 787; Tucker, W. B. 30, p. 214; 31, p. 274; 40a, p. 237.)
*175	C	Lady Lou	J. Denair, Amboy, Calif. (1909)	Approx.	6N	12E	SB	Gold mine; also silver.
*176	C	Lady Luck	J. A. Bolard, Cima, Calif. (1944)	Approx.	15N	14E	SB	Lead-zinc-silver mine.
177	D	Lakeview	W. H. Duvall, 1056 S. Mansfield Ave., Los Angeles, Calif. (1943)	2	7N	7W	SB	
178	D	Lakeview		18	13N	7E	SB	Copper mine; porphyry-limestone contact; shaft, 50 ft.; adits, 600 ft. (Tucker, W. B. 30, p. 214; 31, p. 274.)
*179	C	La Mina Lazula	Jonas & Mayers, Newberry, Calif. (1943)		8N	3E	SB	Silver mine.
		Lava Beds: see Peacock						

SAN BERNARDINO COUNTY—Continued

Number	Class by production	Name of deposit	Name of owner or operator	Location Sec.	T.	R.	B. & M.	Remarks and references
*180	D	Leastalk	Leastalk Gold & Copper Mining Co. (1930)		15N	16E	SB	Gold-copper mine; two shafts 150 ft., in limestone. (Aubury, L. E. 08, p. 330; Cloudman, H. E. 19, p. 787; Tucker, W. B. 30, p. 214; 31, p. 274.)
*181	D	Lewis and Shafer			10N	21E	SB	Shaft 75 ft.; adit 50 ft.; workings 100 ft. (Aubury, L. E. 05, p. 225; 08, p. 336.)
182	C	Liberty	G. A. Childers, Los Angeles, Calif. (1943)	2	6N	4W	SB	Gold-silver mine; produced 1933, 1935-36, 1940.
*183	C	Lily	C. Johnson, Nipton, Calif. (1941)	Approx.	16N	14E	SB	Lead-silver mine; also gold.
*184	C	Lindsay	T. Pianeenti, Needles, Calif. (1907)	Approx.	9N	22E	SB	Copper mine.
*185	C	Littlefield	A. H. Littlefield, Vidal, Calif. (1916)	Approx.	2N	23E	SB	Gold mine; also silver.
186	C	Long Shot	Richardson & Rouchleau, Los Angeles, Calif. (1941)	30, 32	6N	17E	SB	Gold mine; also silver. Fracture in granite. (Tucker, W. B. 40, p. 69; 43b, p. 455.)
*187	C	Lost Loon	S. C. Sampson, Yermo, Calif. (1930)					Gold mine; also silver.
*188	C	Lost Mormon (Barnett)	Lost Mormon Mining Co., Long Beach, Calif. (1938)	Approx.	14N	16E	SB	Lead-gold-silver mine.
		Louise: see under Riverside County						
189	C	Louisiana-California Gold Mining Co.	Louisiana-California Gold Mining Co., Goffs, Calif. (1916)	15, 22	11N	18E	SB	Gold-silver-lead-vanadium mine. (Tucker, W. B. 40, p. 70.)
*190	C	Lucky	J. E. Stevenson, Los Angeles, Calif. (1939)					Lead-silver mine; also gold.
191	C	Lucky Jim	E. J. Morath, Long Beach, Calif. (1930)	26	18N	8E	SB	Lead-silver-copper mine.
*192	C	Lucky Jim			1N	21E	SB	Silver-copper mine: Cu, 5%; opened 1911; 200-ft. shaft connects with 500-ft. adit; 500 ft. other workings. (Tucker, W. B. 31, pp. 274-275.)
*193	C	Lucky Trio	M. E. Post, Essex, Calif. (1943)					Silver mine.

*194	C	Lucy Gray	Lucy Gray Mining Co., Nipton, Calif. (1941)	Approx.	16N	17E	SB	Lead-silver mine; also gold.
*195	C	Lytle Creek			4N	3W	SB	Copper mine; bunches of high-grade Cu ore. (Aubury, L. E. 05, p. 254, 08, p. 335.)
196	C	Mabel	W. Zindell, Essex, Calif. (1934)	3, 10 11	5N	17E	SB	Lead-silver mine; also gold.
		Mabel-Contention: see Big Horn						
197	C	Macedonia (Columbia)	Mrs. R. P. Greenleaf, Los Angeles, Calif. (1943)	3	11N	14E	SB	Gold-lead-zinc-copper mine; vein on porphyry-diorite contact; 350ft.-shaft; several hundred feet workings. (Tucker, W. B. 21, p. 340; 31, p. 348; 43b, p. 447.)
*198	C	Mammoth	W. C. McEwen, Cima, Calif.	Approx.	15N	10E	SB	Gold mine; with silver. (Tucker, W. B. 31, p. 328.)
*199	C	Mansfield	O. D. Mansfield, Hallock, Calif. (1918)					Lead-silver mine; also gold.
*200	C	Mariposa Queen Oil Co.	Mulligan Queen Oil Co., Mulligan, Calif. (1915)	Approx.	3N	17E	SB	Lead-silver mine; also gold.
201	C	Markesan	T. N. Hall, Ludlow, Calif. (1940)	18	6N	8E	SB	Gold mine; also silver; iron-stained breccia. (Gardner, D. L. 40, pl. 2; Tucker, W. B. 40a, p. 238.)
*202	C	Marshall	N. A. Marshall, Bryman, Calif. (1928)					Gold mine; also silver.
		McClintock: see Vulcan						
		McGilroy: see Bell Gilroy						
		McGinnis: see Gold Belt						
*203	C	Metal Extractor	F. L. Rutland, Barstow, Calif. (1936)	Approx.	8N	2W	SB	Gold mine; also silver.
*204	C	Millionaire	R. F. Rosso, Victorville, Calif. (1941)	Approx.	5N	4W	SB	Silver mine; also gold.
*205	C	Mineral Monarch	Staples & Van Kempfz, Ludlow, (Stagg) Calif. (1916)	Approx.	7N	8E	SB	Copper mine; also silver, gold.
*206	C	Minetta	Grimm & Sexton, Trona, Calif. (1917)	Approx.	25S	44E	MD	Lead-silver mine; also gold.
*207	C	Mizpah claim	H. E. Hughes, Trona, Calif. (1923)	Approx.	15N	10E	SB	Gold claim; with silver. (Tucker, W. B. 31, p. 329.
208	B	Mohawk (Fremont)	Universal Industries, Inc., Los Angeles, Calif. (1943)	22, 23	3N	1E	SB	Zinc mine (sphalerite); with pyrite, lead (galena), copper (chalcopyrite), and silver; also gold. (Tucker, W. B. 43, p. 69.)

SAN BERNARDINO COUNTY—Continued

Number	Class by production	Name of deposit	Name of owner or operator	Location Sec.	T.	R.	B. & M.	Remarks and references
209	C?	Mohawk	Ivanpah Copper Co., Los Angeles, Calif. (1943)	18	16N	13E	SB	Lead-zinc mine. (Aubury, L. E. 08, p. 328; Tucker, W. B. 43b, p. 69.)
210	C?	Mohawk (Fremont)	Mohawk Gold & Copper Co. (1919)	29	12N	1E	SB	Gold and copper mine.
*211	C	Mojave Boy	M. A. Hoagland, San Bernardino, Calif. (1941)	Approx.	5N	1W	SB	Gold mine; with silver.
*212	D	Moonlight	S. G. Hubbard, Kingman, Ariz. (1943)					
*213	C	Morgan claim	Morgan & Bradley, Calzona, Calif. (1911)	Approx.	1N	25E	SB	Gold mine; also silver.
		Mountaineer: see under Riverside County						
*214	C	Mt. Ontario	U. S. S. R. & Mining Co. (1926)					Silver mine.
*215	C	Mt. Whipple G. & M. Co.	W. B. Grant, Tucson, Ariz. (1943)					Copper mine.
*216	C	Murray (Henshaw)	J. Murray, Silver Lake, Calif. 1911)	Approx.	3N	1W	SB	Gold mine; with lead, silver. (Tucker, W. B. 31, p. 305.)
217	C?	Nellie May group	Duvall & Klages, Los Angeles, Calif. (1943)	2	7N	7W	SB	Copper mine; copper veins in granite near contact with limestone. (Tucker, W. B. 43b, p. 435.)
*218	C	New Deal	A. C. Housel, Nipton, Calif. (1940)					Silver mine.
*219	C	New Era Mining Devel. Co.	A. Hansen, Cima, Calif. (1929)	Approx.	15N	13E	SB	Lead-silver mine; also gold.
*220	C	New Harmony	Cima Commercial Trust Co., Cima, Calif. (1921)	Approx.	15N	13E	SB	Lead-silver mine; with gold.
221	C	New Trail	New Trail Mining Co., J. F. Kent, pres., Box 867, Riverside, Calif. (1943)	4, 9	15N	14E	SB	Copper mine; with gold, silver; operated 1930-39; high-grade bornite and chalcopyrite ore on fracture intersections with tactite zones; shafts 200, 80 ft.; several hundred feet of workings, stopes. (Tucker, W. B. 30, pp. 216-217; 31, pp. 275-276; 43b, p. 435.)
		New York: see Sagamore						

*222	C	Nickle Plate	Harp & Kunze, Earp, Calif. (1941)	Approx.	1N	25E	SB	Gold mine; with silver.
		Odessa: see Calico-Odessa						
223	C	O. K.	J. D. Dunn, Twentynine Palms, Calif. (1941)	29	1S	12E	SB	Gold mine; with silver. (Tucker, W. B. 31, p. 306.)
224	C	Old Dominion (Ortega)	Anderson & Fremont (1943)	31, 32	7N	6E	SB	Lead-silver mine; with gold.
		Old Ivanpah Copper: see Copper World						
225	C	Old Pete (Yim-Wheelock)	Yim & Wheelock, Ludlow, Calif. (1934)	5	6N	8E	SB	Gold mine. (Gardner, D. L. 40, pl. 2; Tucker, W. B. 43b, p. 456.)
*226	C	O'Meara Copper Co.	O'Meara Copper Co., Manuel, Calif. (1904)					Copper mine.
226A	C	Orange Blossom (see also Gold Coin)		23	7N	11E	SB	Gold-copper-silver mines (Tucker, W. B. 31, p. 276.)
		Orange Blossom Extension: see Gold Coin						
		Ord: see Ord Mountain						
227	C	Ord Mountain (Ord, Osborn, Rio Vista)	Harvey J. Stevenson, 510 S. Spring St., Los Angeles, Calif. (1943)	24	7N	1E	SB	Copper mine, with gold, silver, lead; ore said to run 2-3% Cu, $3-$5 Au; said to have produced $20,000 1929-43; adits 770, 500, 480, 250 ft.; 200-ft. shaft; 200-ft. winze; several-hundred-foot drift. A series of parallel north-trending, east-dipping veins 4-20 ft. wide in andesite; bornite and chalcopyrite carry gold. (Aubury, L. E. 08, p. 336; Cloudman, H. E. 19, p. 789; Crawford, J. J. 96, p. 61; De Groot, H. 90, pp. 528-529; Gardner, D. L. 40, pl. 2; Tucker, W. B. 40a, p. 239; 43b, p. 435; 43a, p. 133.)
		Oriental: see Zenda						
		Oriental & Red Cloud: see Zenda						
228	C	Oro Grande	E. A. Powell, Victorville, Calif. (1941)	17?	6N	4W	SB	Gold mine, with silver. (Tucker, W. B. 30, p. 247.)
*229	C	Oro Treasure and New Year	R. H. Daniels, Daggett, Calif. (1941)		9N	2E	SB	Gold mine; with silver.
		Ortega: see Old Dominion						
		Osborn: see Ord Mountain						
*230	C	Owl Canyon	J. A. McCaskell, Salt Lake City, Utah, (1925)					Lead-silver mine.

SAN BERNARDINO COUNTY—Continued

Number	Class by production	Name of deposit	Name of owner or operator	Location				Remarks and references
				Sec.	T.	R.	B. & M.	
231	C?	Ozark (Big Ten)	J. S. & R. E. Garrison, Victorville, Calif. (1930)	3	6N	4W	SB	Gold-copper mine. (Tucker, W. B. 31, pp. 278, 309.)
		Pacific: see Bagdad-Chase						
232	C	Painsville	Garringer & MacMillan, Los Angeles, Calif. (1940)	24	7N	1E	SB	Copper-gold mine; shaft, 90 ft.; vein, 15 ft.-quartz with copper oxides in monzonite. (Gardner, D. L. 40, pl. 2; Cloudman, H. E. 19, pp. 808-809; Tucker, W. B. 40a, p. 239.)
*233	C	Palm Hill	R. Williams, Cima, Calif. (1909)	Approx.	15N	13E	SB	Silver mine; also gold.
*234	C	P and D	S. Price, Parker, Ariz. (1911)					Lead-silver mine; also gold.
*235	C	Parker B. & T. Co.	Morgan & Bradley, Barstow, Calif. (1913)	Approx.	8N	1W	SB	Gold mine; also silver.
236	D	Pauper's Dream	R. L. Brooks, Yucaipa, Calif. (1930)	4	2S	1W	SB	Gold-copper mine; shaft 30 ft.; 6-in. quartz vein. (Tucker, W. B. 30, p. 219; 31, p. 279.)
237	C	Paymaster (Whitney)	W. N. Thompson, Whittier, Calif. (1944)	23	13N	10E	SB	Gold mine. (Tucker, W. B. 31, p. 329.)
238	D	Peacock (Lava Beds)		23	11N	18E	SB	Copper indications. (Aubury, L. E. 05; p. 254; 08, p. 335.)
*239	C	Perseverance	Eltistie, Rohr, & Richards, Goffs, Calif. (1920)	Approx.	10N	14E	SB	Lead-silver mine; also gold. (Tucker, W. B. 30, p. 281.)
*240	C	Peterson	Peterson Lease, Maruba, Calif. (1917)					Lead-silver mine.
241	C	Pilot	A. W. Eaton, Goffs, Calif. (1916)	29	10N	14E	SB	Gold mine; also lead, silver. (Tucker, W. B. 30, p. 354.)
242	C	Pioneer	J. Ford Jr., Johannesburg, Calif. (1942)	31	29S	41E	MD	Gold mine; also silver.
243	D	Piper group		25	10N	1W	SB	Gold-copper mine; quartz veins in schist. (Tucker, W. B. 30, p. 219; 31, p. 279.)
244	B	Piute	R. W. Crampton, Cima, Calif. (1919)	26	9N	18E	SB	Gold mine; also zinc, lead, silver; produced 1916-17. (Tucker, W. B. 31, p. 310.)
*245	C	Plato	J. S. Lutes, East Pasadena, Calif. (1934)					Gold mine; also silver.

*246	C	Portland	Carlson & Kendall, Searchlight, Nev. (1908)					Lead-silver mine.
*247	C	Pozo	A. F. Stotts, Cima, Calif. (1927)	Approx.	15N	13E	SB	Gold mine; also silver.
248	D	Price group	A. C. Price, Long Beach, Calif. (1930)	27	6N	2W	SB	Copper mine; copper-stained barite; shaft, 35 ft.; adit. (Tucker, W. B. 31, p. 279.)
*249	C	Prospect	M. D. House, Goffs, Calif. (1927)	Approx.	9N	18E	SB	Gold mine; also silver.
250	C	Providence	P. Thibedeau, Kelso, Calif. (1931)	32	10N	14E	SB	Lead mine; also silver. (Tucker, W. B. 31, p. 354.)
*251	D	Pyramid			3N	22E	SB	
*252	C	Rainbow	L. Griffiths & Son, Fredonia, Ariz. (1936)	Approx.	25S	44E	MD	Gold mine; also silver.
253	C	Ramsey (Wheeler)	Ramsey Mining Co., Lucerne Valley, Calif. (1942)	2, 3	3N	2W	SB	Gold mine; also silver, lead. (Tucker, W. B. 40, p. 72; 43b, p. 458.)
		Red Bridge: see Big Four						
*254	C	Red Cloud	A. McCuistion, Daggett, Calif. (1942)	Approx.	8N	1E	SB	Silver mine; also gold.
*255	C	Red Jacket	A. Del Mar, Victorville, Calif. (1934)		2N	2E	SB	Lead-silver mine; also gold.
256	C?	Revenue Copper	J. L. Johnson, Cima, Calif. (1943)	4	15N	14E	SB	Copper mine; carbonates, oxides, chalcopyrite, and bornite in vein along porphyry intrusion in limestone. (Tucker, W. B. 43b, p. 436.)
*257	B?	Revenue Mine			3N	23E	SB	
		Riggs: see Alta						
*258	C	Rincon Mines Co.	H. W. McDowell, Parker, Ariz. (1918)		4N	25E	SB	Copper mine; two cars shipped, 5% Cu, $22 Au; promising; open cuts on 1-6 ft. east-trending vein. (Newman, M. A. 22, pp. 308-309; Tucker, W. B. 30, p. 220; 31, p. 279.)
		Rio Vista: see Ord Mountain						
*259	C	Riverside Gold Mining and Milling Co.	J. H. Ware, Kingman, Ariz. (1914)					Gold mine; also silver.
260	C	Riverview (Tuscarora)	Desert Mining Co., Parker, Ariz. (1944); J. W. Stewart, Needles, Calif. (1937)	1	1N	24E	SB	Copper-gold mine; also silver; oxides and carbonates on contact of schist and limestone or diorite; produced 1939, 1944. (Cloudman, H. E. 19, p. 791; Tucker, W. B. 31, p. 280; 43b, p. 436.)
261	C	Roosevelt	Roosevelt Mines, Inc., Ludlow, Calif. (1944)	11	6N	3W	SB	Copper-gold mine; also silver.
*262	D	Rosalia Mining Co.			9N	22E	SB	Copper-gold mine; little development. (Cloudman, H. E. 19, p. 790.

SAN BERNARDINO COUNTY—Continued

Number	Class by production	Name of deposit	Name of owner or operator	Location				Remarks and references
				Sec.	T.	R.	B. & M.	
263	C	Rose		20	2N	3E	SB	Gold mine; with copper; principally free Au; Cu ore occurs in pockets and is separately shipped: 1,000-ft. shaft, 500-ft. adit, 2,000-ft additional workings. (Aubury, L. E. 06, p. 252; 08, p. 334.)
*264	C	Ross	R. B. Gill, Los Angeles, Calif. (1927)	Approx.	15N	13E	SB	Lead-silver mine; also gold.
*265	B	Run Over Consolidated Copper Mine	Von Trigger Copper Co. (1927)	Approx.	10N	17E	SB	Copper-gold mine; produced 1926-27, 1929-30.
266	C	Sagamore (New York)	Calif. Sulphur Co., Ivanpah, Calif. (1944); Ivanpah Copper Co., Dr. L. D. Godshall, 722 S. Oxford St., Los Angeles, Calif. (1931)	35	14N	16E	SB	Lead-zinc-silver-copper-tungsten mine; also gold; produced 1907-08, 1917, 1942-44; adits 700, 600, 200 ft.; shafts 100, 50 ft.; other workings; northeast-striking, vertical veins 2-12 ft. wide, crosscutting schist country rock and cut by dikes; minerals include huebnerite, copper sulphides, zinc and antimony sulphides, in quartz gouge; tungsten is more important. (Aubury, L. E. 08, pp. 331-333; Cloudman, H. E. 19, p. 790; Jenkins, O. P. 42, p. 350; Tucker, W. B. 30, p. 220; 31, p. 279; 43, p. 67; 43b, p. 436.)
*267	C	Said	B. K. Said, Cima, Calif. (1913)	Approx.	15N	13E	SB	Gold mine; also silver.
*268	C	Sanburn	J. Sanburn, Calzona, Calif. (1913)	Approx.	1N	24E	SB	Copper mine.
269	C	Santa Fe (Arlington, Black Hawk)	Beverly Oil Co., Lucerne Valley Calif. (1942)	5, 8, 9, 16, 17	3N	2E	SB	Gold mine; also silver, lead. (Tucker, W. B. 43b, p. 460.)
270	C	Santa Fe	Wortley Cons. Mines, Inc., San Fernando, Calif. (1943)	6	30S	41E	MD	Silver mine; also gold. (Tucker, W. B. 43b, p. 487.)
*271	C	Savahai	Roberts & Thomas, Vidal, Calif. (1941)	Approx.	2N	23E	SB	Gold mine; also silver.
*272	C	Sheep claim	F. M. Kelly, Needles, Calif. (1902)	Approx.	8N	22E	SB	Gold mine.
273	C	Silver Dome	Silver Dome Mining Co., Los Angeles (1930)	3	32S	42E	MD	Gold-silver-copper mine; shaft, 303 ft.; 150 ft. of drifts on 4-8 ft. veins in limestone near granite; bornite in four parallel veins; chalcopyrite, pyrite, bornite, calcite, and quartz on hanging wall of diabase dike. (Tucker, W. B. 23d, p. 172; 31, pp. 279, 313.)
		Silver King: see Zenda						

*274	C	Silver King and Waterloo	Anthony & Mayne, Yermo, Calif. (1941)	Approx.	15N	10E	SB	Gold mine; also silver. (Tucker, W. B. 31, p. 331.)
*275	C	Silver Moon	Miller & Brown, Needles, Calif. (1937)	Approx.	8N	22E	SB	Gold mine; also silver.
*276	C	Silver Reef	Cresse & McLaughlin, Los Angeles, Calif. (1941)	Approx.	4N	2E	SB	Lead-silver mine; also gold.
276A	C	Silver Rule (Chambers)	Pacific Lead & Silver Mining Co., Los Angeles, Calif. (1938)	6	19N	10E	SB	Lead-silver-zinc mine; also gold. Mine recorded in Inyo County, is actually in San Bernardino County. (Tucker, W. B. 38a, pp. 455, 479, pl. 3; Waring, C. A. 19, p. 108.)
*277	C	Smuggler group	Mrs. J. W. Taylor, Westend, Calif. (1941)	Approx.	26S	44E	MD	Lead-silver mine.
*278	C	South Western Lead Co.	E. W. Fisher, Bagdad, Calif. (1913)	Approx.	7N	10E	SB	Lead-silver mine; also gold.
279	B	Standard	C. E. Johnson, Cima, Calif. (1910)	18	15N	14E	SB	Silver-gold-lead mine; produced 1906-10. (Aubury, L. E. 08, p. 33; Cloudman, H. E. 19, p. 790; Tucker, W. B. 31, pp. 279-280.)
280	C	Standard No. 2	A. Hansen, Cima, Calif.	18	15N	14E	SB	Copper mine; also lead, silver, gold. (Tucker, W. B. 31, p. 279.)
*281	C	States Mutual Cons. Co.	V. A. Bruener, Leastalk, Calif. (1913)					Silver mine.
*282	C	Steece	H. C. Steece, Vidal, Calif. (1912)	Approx.	2N	23E	SB	Gold mine; also silver.
*283	C	Stemwinder	Stemwinder Mining & Devel. Co., Goffs, Calif. (1917)	Approx.	9N	22E	SB	Lead-silver mine; also gold.
284	C	Stonewall (Stonewall Jackson)	M. A. Kiwisar, Jean, Nev. (1942)	10	17N	13E	SB	Lead-silver mine; also gold; predominantly silver; active 1881-96, 1927-28, 1938-42. (Tucker, W. B. 21, p. 342; 24, p. 94; 30, p. 285.)
285	C	Sunnyside	Bussey & Bain, Whitewater, Calif. (1943)	27	2N	3E	SB	Gold-tungsten mine; quartz in granite and limestone. (Tucker, W. B. 41, p. 586; 43b, p. 507.)
*286	C	Sunshine Copper Co.	C. M. McFarlane, Parker, Ariz. (1929)					Lead-silver-copper mine.
*287	C	Swastika	A. E. Robinson, Barstow, Calif. (1938)	Approx.	14N	1E	SB	Silver mine, also lead, gold. (Hulin, C. D. 25, p. 139.)
*288	C	Sweepstakes	D. L. Velman, Redlands, Calif. (1940)	Approx.	25S	44E	MD	Silver mine, also gold.
*289	C	Tanzer	C. D. Tanzer, Hallock, Calif. (1918)					Lead-silver mine.

SAN BERNARDINO COUNTY—Continued

Number	Class by production	Name of deposit	Name of owner or operator	Location Sec.	Location T.	Location R.	Location B. & M.	Remarks and references
290	D	Thelma and Mammoth		25	14N	7E	SB	Copper-gold-silver mine; shallow pits on quartz veins in granite. (Tucker, W. B. 31, p. 280.)
*291	C	Three Star	May & Reed, Lucerne Valley, Calif. (1933)	Approx.	3N	1W	SB	Gold mine, also silver.
		Three States: see Break of Day						
		Thunderer: see Calico-Odessa						
292	C	Tip Top		36	7N	5E	SB	Silver-copper mine; adits; wide, shear zone replacement deposit, strike N. 50° W., dip 70° NE.; sorted ore assaying 33% Cu, 15 oz. Ag shipped in early days; copper is in footwall of silver lode. (Crawford, J. J. 96, p. 61; Storms, W. H. 93, pp. 354-358; Tucker, W. B. 30, p. 285.)
		Toltec: see Halloran Springs						
		Total Wreck: see Burcham						
293	C?	Trio group	H. Lias, Ivanpah, Calif. (1943)	21, 22	14N	16E	SB	Copper mine; bornite and chalcopyrite; in fractures in limestone. (Tucker, W. B. 43b, p. 437.)
		Tuscarora: see River View						
294	C	Uranium claim	Calif. Rand Silver, Inc., Randsburg, Calif. (1928)	1, 12 6, 7	30S 30S	40E 41E	MD MD	Gold mine; also silver.
295	C	Vanderbilt	Campbell Estate, Ivanpah, Calif. (1942)	3	14N	16E	SB	Gold mine; also silver, lead. (Tucker, W. B. 34, p. 325; 43b, p. 464.)
*296	C	Vaughn & Benedict	Vaughn & Benedict, Needles, Calif. (1913)	Approx.	9N	22E	SB	Gold mine, also silver.
297	D	Vida (White Mountain)		6	3N	2E	SB	
*298	C	Vidal Mining Co.	Vidal Mining Co., Vidal, Calif. (1916)	Approx.	1S	23E	SB	Gold mine, also silver.
299	D	Virginia group	S. G. Hubbard, Box 694, Kingman, Ariz. (1943)	15	3N	24E	SB	

300	B	Vontrigger (Von Trigger, Calif., Gold Copper Co.)	H. C. Mills, Los Angeles, Calif. (1944); Guy L. Goodwin, Long Beach, Calif.; T. P. Scaroni et al., Santa Maria, Calif. (1943)	2, 10 11 15	11N	17E	SB	Copper-gold mine, also silver; chalcopyrite, and pyrite in two veins, on contact of granite, quartz diorite, and gabbro; adit, 30 ft.; wide E-W gossan. Produced 1908, 1912-17, 1926-29, 1940, 1944. (Aubury, L. E. 05, p. 251; 08, p. 333; Cloudman, H. E. 19, p. 785; Tucker, W. B. 30, p. 207; 31, p. 267; 43, p. 66.)
301	C	Vulcan (McClintock)	Miss H. C. King, Los Angeles, Calif. (1943)	11	5N	15E	SB	Gold-copper mine, also silver; gold vein in quartz diorite; copper vein in hanging wall of gold vein, at contact of quartz diorite and limestone. (Tucker, W. B. 43a, p. 137.)
302	C	War Eagle	L. W. Osborne, Los Angeles, Calif. (1943)	2, 3	4N	10E	SB	Silver-lead mine; also molybdenum and vanadium. (Tucker, W. B. 31, p. 359; 34, p. 325; 43b, p. 489.)
303	C	Waterloo	Waterloo Mining Co., Anaheim, Calif. (1943)	9	10N	1E	SB	Silver mine, also gold; vein on fault. (Gardner, D. L. 40, pl. 2; Tucker, W. B. 40a, p. 246; 43b, p. 489.)
		Wheeler: see Ramsay						
304	C	Whipple Mountain	E. M. Wardwell, Vidal, Calif. (1911)	24?	3N	23E	SB	Gold mine; also silver.
		White Mountain: see Vida						
		Whitney: see Paymaster						
*305	C	Williams	E. Wilton, Earp, Calif. (1941)	Approx.	1N	25E	SB	Gold mine, also silver.
306	C	Winifred group		29, 30	7N	11E	SB	Copper-gold mine; adit, 300 ft.; winzes; production 1908. (Cloudman, H. E. 19, p. 791.)
*307	C	Wrambolt	C. H. Wrambolt, Victorville, Calif. (1913)	Approx.	5N	2W	SB	Gold mine, also silver.
		Yim-Wheelock: see Old Pete						
308	C	Yucca Queen	Yucca Metals Co. (1942)	17	16N	13E	SB	Lead-silver mine. (Tucker, W. B. 43b, p. 491.)
309	C	Zenda (Oriental, Silver King, Oriental and Red Cloud)	Zenda Gold Mining Co., Los Angeles, Calif. (1942)	15, 22	10N	1E	SB	Silver-lead mine, with gold; fractures in rhyolite tuff. (Tucker, W. B. 31, map opp. p. 344; 40, p. 247; 43b, p. 491.)

* Not shown on map because of lack of definite location.
° Not shown on map because of crowded condition.

SAN DIEGO COUNTY

Number	Class by production	Name of deposit	Name of owner or operator	Location: Sec.	Location: T.	Location: R.	Location: B. & M.	Remarks and references
		Barona: see Daley						
1	B	Daley (Barona)	Sarah M. Daley, San Diego, Calif. (1939)	11	13S	1E	SB	Copper mine; adit 525 ft.; shaft 115 ft.; drifts 105, 50 ft.; on mineralized zone at contact of granite and schist; copper oxides, malachite, azurite, and chalcopyrite disseminated over area 50 by 150 ft.; only important activity 1916-18, when about 175,000 lbs. Cu was smelted on property; subsequent milling attempts have yielded little production. (Aubury, L. E. 05, p. 260; 08, p. 345; Merrill, F. J. H. 16, p. 667; Rand, L. H. 31, pp. 649-650; Tucker, W. B. 24, p. 370; 25, p. 330; 39, pp. 13-14.)
		Danes Lea: see Encinitas						
2	C	Eagle	A. P. Frary, Julian, Calif. (1939)	31, 32	12S	4E	SB	Gold mine; also silver, pyrite. (Tucker W. B. 39, p. 17.)
3	C	Encinitas (Danes Lea)	W. C. Harland, Encinitas, Calif. (1917)	32, 33 4, 5	12S 13S	3W 3W	SB SB	Chalcopyrite vein in porphyry; idle for years; shafts 280, 100 ft.; on 3-ft. vein. (Aubury, L. E. 05, p. 259; 08, p. 344; Merrill, F. J. H. 16, p. 668; Tucker, W. B. 25, p. 331; 39, p. 14.)
4	C	Friday	Friday Copper Mining Co., San Diego, Calif. (1939)	15	13S	4E	SB	Nickel mine; shaft 175 ft. with two levels; also adits; ore is pyrrhotite at depth, and similar to that at Sudbury, Ont.; samples said to contain 4% nickel, 2% cobalt, 6% arsenic, and some copper sulphides and carbonates. (Merrill, F. J. H. 16, p. 666; Rand, L. H. 31, p. 527; Tucker, W. B. 25, p. 330; 39, p. 31.)
*5	C	Magdalena	Descanso Mining Corp., San Diego, Calif. (1936)	Approx.	12S	4E	SB	Gold-silver mine.
		Old Owens: see Owens						
6	B	Owens (Old Owens)	W. A. Williams, Julian, Calif. (1909)	31	12S	4E	SB	Gold mine; also silver; quartz vein in schist; produced 1904. (Tucker, W. B. 39, p. 24.)

* Not shown on map because of lack of definite location.

SAN LUIS OBISPO COUNTY

Number	Class by production	Name of deposit	Name of owner or operator	Location: Sec.	Location: T.	Location: R.	Location: B. & M.	Remarks and references
*1	D	Alpha	H. Sevier, Lompoc, Calif. (1934)		29S	11E	MD	Copper mine. (Franke, H. A. 35, p. 417.)
2	D	Barbara	E. C. Sevier, Arroyo Grande, Calif. (1934)	3	29S	11E	MD	Copper mine. (Franke, H. A. 35, p. 417.)
*3	D	Big Bend	H. Sevier, Lompoc, Calif. (1934)		29S	11E	MD	Copper mine. (Franke, H. A. 35, p. 417.)
4	D	Bonanza group	Howard Sevier, Lompoc, Calif. (1935)	8?	29S	11E	MD	Copper mine. (Franke, H. A. 35, p. 417.)
		Drought: see First Chance						
5	D	First Chance (Drought, Skyscraper)	S. E. Hogue, 1506 Chono St., San Luis Obispo, Calif. (1935)	27	28S	11E	MD	Copper mine; copper and nickel in porphyry and granite; adits 180, 50 ft.; on vein said to be 10 ft. (Aubury, L. E. 05, p. 148; 08, p. 173; Franke, H. A. 35, p. 418; Laizure, C. McK 25c, p. 512; Logan, C. A. 19, p. 686.)
6	D	Florence	E. C. Sevier, Arroyo Grande, Calif. (1934)	3	29S	11E	MD	Copper mine. (Franke, H. A. 35, p. 417.)
		Gloria: see Guerro						
		Goodwill: see Los Osos						
		Guadalupe: see Guerro						
7	D	Guerro (Gloria, Guadalupe, Tassajara, Tiptop)		25	29S	12E	MD	Copper mine. (Aubury, L. E. 05, pp. 147-148; 08, pp. 173 174; Franke, H. A. 35, p. 418; Laizure, C. McK 25c, p. 511.)
8	D	Hazzard group		32	28S	11E	MD	
9	D	Hobson	W. K. Hobson, Cayucos, Calif. (1924)	34	29S	11E	MD	Copper mine; chrome and copper in serpentine. (Laizure, C. McK 25c, p. 511; Logan, C. A. 19, p. 686.)
		Little Band: see Little Bend						
10	D	Little Bend group (Little Band)	E. C. Sevier, Arroyo Grande, Calif. (1934)	3	29S	11E	MD	Copper mine. (Franke, H. A. 35, p. 417.)
		Lonestar and Fern: see Silver Swan						
11	B	Los Osos (Goodwill)	Mrs. E. Filipponi, 1223 Higuera St., San Luis Obispo, Calif. (1935)	27	30S	11E	MD	Copper mine; also gold, silver; shaft 230 ft.; adit 235 ft. on 4 to 12 ft. vein in sandstone and shale; workings cleaned out by Ogden Chase, 1934; project abandoned; in sixties 100 tons 18% ore shipped to Boston and Swansea. (Aubury, L. E. 05, p. 147; 08, pp. 192-193; Browne, J. R. 67, p. 152; Franke, H. A. 35, p. 417; Laizure, C. McK 25c, p. 511; Logan, C. A. 19, p. 686.)

SAN LUIS OBISPO COUNTY—Continued

Number	Class by production	Name of deposit	Name of owner or operator	Location				Remarks and references
				Sec.	T.	R.	B. & M.	
*12	D	Lucky Jack	H. Sevier, Lompoc, Calif. (1934)		29S	11E	MD	Copper mine. (Franke, H. A. 35, p. 417.)
		McCles: see Schneider and McCles						
*13	D	North Star	H. Sevier, Lompoc, Calif. (1934)		29S	11E	MD	Copper mine. (Franke, H. A. 35, p. 417.)
14	D	Prodigal Son		30	28S	11E	MD	Copper mine; adit 100 ft. in serpentine. (Aubury, L. E. 05, p. 149; 08, p. 193; Franke, H. A. 35, p. 419; Laizure, C. McK 25c, p. 511.)
15	D	Refugio		33?	29S	12E	MD	Copper mine. (Franke, H. A. 35, p. 419.)
16	D	Ridge	Hogue & Hogue, San Luis Obispo, Calif. (1934)	28	28S	11E	MD	Copper mine; nickel with trace of copper. (Franke, H. A. 35, p. 418.)
17	C	San Ramon	G. W. Hampton et al., 712 Marsh St., San Luis Obispo, Calif. (1935)	3	29S	11E	MD	Copper mine; adit 140 ft.; shaft 50 ft. on 5 to 11 ft. vein; some production in sixties. (Franke, H. A. 35, p. 418.)
18	D	Schneider and McCles		14	29S	11E	MD	Copper mine. (Aubury, L. E. 05, p. 148; 08, p. 173; Franke, H. A. 35, p. 419; Laizure, C. McK 25c, p. 511.)
19	C	Silver Swan (Lonestar and Fern)	Maud Terris, 1421 Park St., Paso Robles, Calif. (1934)	26	28S	11E	MD	Copper mine; adit 300 ft.; some production; assessment kept up. Franke, H. A. 35, p. 417.)
		Skyscraper: see First Chance						
20	D	Take a Chance group		27	29S	12E	MD	Copper mine; native copper in serpentine; some development. Franke, H. A. 35, p. 419; Laizure, C. McK 25c, p. 512; Logan, C. A. 19, p. 686.)
		Tassajara: see Guerro						
		The Barbara: see Barbara						
		Tiptop. see Guerro						
21	D	Yoakum Tract	Jesse Yoakum, San Luis Obispo, Calif. (1935)	1	31S	12E	MD	Copper mine; in 1934 a 350-ft. incline was sunk by Ogden Chase; only low-grade ore developed; project abandoned. Franke, H. A. 35 p. 418.)

* Not shown on map because of lack of definite location.

SANTA BARBARA COUNTY

Number	Class by production	Name of deposit	Name of owner or operator	Location Sec.	Location T.	Location R.	Location B. & M.	Remarks and references
1	D	Alexander Villa		36	10N	36W	SB	
2	C?	Copper King		5	7N	29W	SB	Copper mine; adit 1,100 ft. driven to cut copper-bearing quartz vein. (Huguenin, E. 19, p. 735; Tucker, W. B. 25, p. 541.)
3	C	Figueroa	F. F. Tunnell, Santa Maria, Calif. (1940)	36	8N	30W	SB	Silver-gold mine.
4	D	Laguna Ranch		2	7N	30W	SB	Copper mine; two adits on 40-ft. zone of mineralized shale. (Tucker, W. B. 25, p. 541.)
*5	C	Tunnel (may be Copper King)	Antolini & Johnson, Santa Barbara, Calif.	Approx.	7N	29W	SB	Silver-gold mine.

* Not shown on map because of lack of definite location.

SANTA CLARA COUNTY

Number	Class by production	Name of deposit	Name of owner or operator	Location Sec.	Location T.	Location R.	Location B. & M.	Remarks and references
*1	C	Hahn Ranch		--------	8S	1E	MD	Worked in 1865. (Irelan, W. Jr. 88, p. 549.)
2	D	Hooker Creek	H. C. Adair, San Francisco, Calif. (1929)	10	9S	1W	MD	Copper mine (chalcopyrite, malachite, azurite); adits 300, 185 ft.; worked 1917-18. (Franke, H. A. 30, p. 7; Huguenin, E. 21a, p. 184.)
3	D	Laguna Seca Ranch		36	8S	2E	MD	(Weber, A. H. 90, p. 56.)
4	D	Masson Ranch	Clyde House (1943)	16	10S	5E	MD	

* Not shown on map because of lack of definite location.

SIERRA COUNTY

Number	Class by production	Name of deposit	Name of owner or operator	Location Sec.	T.	R.	B. & M.	Remarks and references
		Alaska: see Sierra Alaska						
1	D	Antelope Neck		27	21N	15E	MD	A wide, patented zone, showing copper mineralization. (Aubury, L. E. 05, p. 161; 08, p. 189; MacBoyle, E. 20, p. 30.)
2	D	Bassett Pride		11	20N	12E	MD	Native copper; adit. (Aubury, L. E. 05, p. 161; 08, p. 189; MacBoyle, E. 20, p. 30.)
3	C	Bonanza (Edwards)	F. F. Guild, Oakland, Calif. (1903)	2, 3	18N	10E	MD	Gold mine; also silver. (Averill, C. V. 42, p. 51.)
4	D	Chips (Swastika)	Swastika Mining Co., San Francisco, Calif. (1942)	26, 27	20N	12E	MD	Gold mine; said to contain molybdenum. (Averill, C. V. 42, p. 52.)
5	D	Copper Mine		13	20N	12E	MD	Adit 400 ft. (Aubury, L. E. 03a, p. 12; MacBoyle, E. 20, p. 30.)
6	D	Copper Mine		1	21N	10E	MD	Drift (adit), 180 ft.; vein 14 ft. (Aubury, L. E. 03a, p. 12.)
7	D	Depot Hill	J. F Joubert, Camptonville, Calif. (1942)	19	19N	9E	MD	Gold mine; copper mineralization in serpentine. (Aubury, L. E. 03a p. 12; Averill, C. V. 42, p. 54; Crawford, J. J. 94, p. 70; 96, p. 63.)
		Edwards: see Bonanza						
8	C	Empire (Gold Valley)	A. & P Bachels, Goodyears Bar, Calif. (1942)	25, 26	21N	11E	MD	Gold mine; also silver. (Averill, C. V. 42, p. 54.)
9	C	Gold Point (Gray Eagle)	Tombstone Development Co., Downieville, Calif. (1939)	28	20N	11E	MD	Gold mine; also silver, lead. (Averill, C. V. 42, p. 56.)
		Gold Valley: see Empire						
		Gray Eagle: see Gold Point						
10	D	Hapgood and Miller		30	20N	13E	MD	Vein 15 ft.; sulphides, oxide. (Aubury, L. E. 05, p. 162; 08, p. 189; MacBoyle, E. 20, p. 30.)
11	C	Kenton	Dr. Royal, Pasadena, Calif (1942)	4	18N	10E	MD	Gold mine; also silver. (Averill, C. V. 42, p. 58.)
12	D	Lassiat		10	21N	10E	MD	Said to be 60 ft. wide. (Aubury, L. E. 03a, p. 12; MacBoyle, E. 20, p. 31.)
		Miller: see Hapgood and Miller						
		Oriental: see Oriental Gold Star						

13	C	Oriental Gold Star (Oriental)	F. S. Drescher, Sacramento, Calif. (1942)	4 33	18N 19N	10E 10E	MD MD	Gold mine; also silver. (Averill, C. V. 42, p. 62.)
14	C	Original Sixteen to One	Original Sixteen to One Mine, Inc., San Francisco, Calif. (1944)	3, 4 34	18N 19N	10E 10E	MD MD	Gold mine; also silver, lead. (Averill, C. V. 42, p. 62.)
15	D	Peacock		29	19N	9E	MD	Adit 75 ft.; shaft 9 ft. (Aubury, L. E. 05, p. 12.)
16	C	Scotia	E. L. Crafts, Grass Valley, Calif. (1934)	4	18N	10E	MD	Gold mine; also silver, lead. (Crawford, J. J. 94, p. 272.)
17	C	Sierra Alaska (Alaska)	Sierra Alaska Mining Co., Pike, Calif. (1942)	5, 8	18N	9E	MD	Gold mine; also silver, lead. (Averill, C. V. 42, p. 50.)
18	C	Sierra Buttes	Hayes Co., San Jose, Calif. (1941)	20 28, 29 31	20N 21N	12E 12E	MD MD	Gold mine; also silver. (Averill, C. V. 42, p. 64.)
19	C	Sierra Homestake	Myrtle M. Gallinger, Tahoe City, Calif. (1942)	1	20N	12E	MD	Copper mine; also gold and traces of molybdenite; small shipments of copper ore; adits 140, 140, and 75 ft. (Averill, C. V. 42, pp. 17, 64; Logan, C. A. 29, pp. 170-171.)
		Swastika: see Chips						
20	C	Tightner	Original Sixteen to One Mine, Inc., San Francisco, Calif. (1942)	27	19N	10E	MD	Gold mine; also silver. (Averill, C. V. 42, p. 66)
21	C	Zuvar	G. Zuver, Sierra City, Calif. (1942)	19	20N	12E	MD	Copper mine; shaft 40 ft.; some ore shipped prior to 1902.

SHASTA COUNTY

Number	Class by production	Name of deposit	Name of owner or operator	Location Sec.	T.	R.	B. & M.	Remarks and references
*1	C		C. G. Taylor, Kennett, Calif. (1941)	Approx.	34N	5W	MD	Gold mine; also silver
*2	C		R. S. & E. O. Moore, Redding, Calif. (1942)	Approx.	32N	6W	MD	Gold mine; also silver.
*3	C		C. L. Probstel, Shasta, Calif. (1943)	Approx.	32N	6W	MD	Gold mine; also silver.
		Abbott: see Fluke and Abbott						
4	A	Afterthought (Peck)	Afterthought Zinc Mining Co. (Glidden Co.), 11001 Madison Ave., Cleveland, Ohio (1942); E. L. Ralston, gen. mgr., Ingot, Calif.	10, 11	33N	2W	MD	Zinc mine (sphalerite); also copper (chalcopyrite), lead, silver, gold; produced 1905-07, 1917-20. (Aubury, L. E. 05, p. 92; 08, pp. 102, 105; Averill, C. V. 39, pp. 174, 176; Brown, G. C. 16a, pp. 758, 759, 760-761, 806, 809; Crawford, J. J. 94, p. 377; 96, p. 610; Fairbanks, H. W. 93, p. 32; Laizure, C. McK 21, p. 516; Logan, C. A. 24, p. 16; Tucker, W. B. 22, p. 595; 23, p. 8; 24a, p. 425; 26, pp. 143, 211.)
5	C	Akers group	Nannie Schonrock (1944)	6, 7	33N	5W	MD	Copper mine (chalcopyrite); also pyrite; between Mammoth and Balaklala; small lenses 2-6% Cu ore, $2 Au; prominent gossan; four adits; 500 ft. of drifts. (Averill, C. V. 39, p. 176; Laizure, C. McK 21, p. 516; Tucker, W. B. 23a, p. 55; 24a, p. 426; 26, pp. 144-145.)
6	D?	Alice		19	32N	5W	MD	Copper mine.
		Alleghany: see Little Nellie						
		American Girl group: see Thompson?						
7	D	Americus		10, 11	31N	6W	MD	South of copper belt; shaft, 100 ft.; adit, 210 ft. (Aubury, L. E. 02a, p. 4.)
		Anchor Lode: see Rising Star						
		Anderson group: see Mammoth						
8	C	Arps group	D. V. Saeltzer, Antone Saegel, et al., 2100 West St., Redding, Calif. (1938)	20, 21 28	34N	3W	MD	Copper mine (chalcopyrite); also zinc (sphalerite), silver, gold, pyrite; produced in 1917; on Copper City lode; 15 patented (?) claims; 250 acres; small lenses of ore; several carloads shipped; 3,000 ft. of workings. (Aubury, L. E. 05, p. 96; 08, p. 110; Averill, C. V. 39, p. 176; Brown, G. C. 16, p. 761; Tucker, W. B. 23a, pp. 89, 90.)
*9	C	Art Brown	A. Brown, Schilling, Calif. (1918)	Approx.	32N	6W	MD	Gold mine; also silver

°10	C	Backbone	Backbone Gold Mining Co., Kennett, Calif. (1939)	28, 33	34N	5W	MD	Copper mine; also gold, silver, lead. (Averill, C. V. 39, pp. 124, 176.)
11	A	Balaklala (Windy Camp)	First National Copper Co., San Francisco, Calif. (1944)	12, 13 14	33N	6W	MD	Copper (chalcopyrite) and zinc (sphalerite) mine; also silver, gold; produced 1908-11, 1913-19, 1924-28. (Aubury, L. E. 05, p. 84; 08, pp. 88-94; Averill, C. V. 33, pp. 7-8; 34a, p. 305; 39, pp. 126, 131, 177; Brown, G. C. 16, pp. 758, 761, 771; Crawford, J. J. 94, p. 245; 96; p. 63; Laizure, C. McK 21, p. 516; Tucker, W. B. 22, pp. 138, 296, 23, p. 8; 24, p. 427; 26, p. 145.)
°12	D	Bald Eagle	M. V. Ballou, Anderson, Calif. (1939)	10	34N	3W	MD	Copper mine; north of Bully Hill. (Aubury, L. E. 02a, p. 9; Brown, G. C. 16a, p. 762; Averill, C. V. 39, p. 177.)
		Baxter: see Baxter Winthrop						
13	B	Baxter-Winthrop (Baxter, Winthrop, Copper City)	Calif. Zinc Co., Oakland, Calif. (1944)	28	34N	3W	MD	Copper mine; worked as silver mine in 1880's; adits, 3000 ft.; drifts, 1000 ft., caved. (Aubury, L. E. 08, p. 107; Averill, C. V. 39, p. 177; McGregor, A. 90b, p. 638; Tucker, W. B. 24a, p. 428; 26, p. 146.)
		Bennington: see Little Nellie						
14	C	Benson (Janice)	H. F. Withington, Redding, Calif. (1936)	12, 14	32N	6W	MD	Gold mine; also silver. (Averill, C. V. 39, p. 177.)
		Big Buck: see Blue Jay						
		Bismarck group: see Jaegel						
15	C	Black Diamond	Black Diamond group, Redding, Calif. (1939)	5	31N	5W	MD	Gold mine; also silver; chalcopyrite, pyrrhotite, and magnetite on contact of diorite and limestone; south of belt; 80-ft. adit. (Aubury, L. E. 02a, p. 4; Averill, C. V. 39, pp. 132, 177.)
16	C	Black Diamond group	Black Diamond Group, Redding, Calif. (1939)	2, 3	33N	4W	MD	Copper mine (chalcopyrite); also pyrrhotite and magnetite; small ore bodies; considerable development. (Aubury, L. E. 02a, p. 9; Averill, C. V. 39, p. 177; Tucker, W. B. 26, p. 146.)
17	C	Blue Jacket	U. S. Government (1944)	25	34N	4W	MD	Produced 1896 from 4-ft. vein. (Crawford, J. J. 94, p. 69.)
°18	D?	Blue Jay (Big Buck, Dome)		23, 24 25, 26	33N	6W	MD	
°19	D	Bohematosh	S. P. Land Co.	25	33N	6W	MD	(Aubury, L. E. 05, p. 88; 08, p. 97.)
20	C	Brunswick (Miners group)	E. J. Brenton, Sierra Madre, Calif. (1942)	20	33N	7W	MD	Gold mine; also silver. (Averill, C. V. 39, p. 185.)
°21	D	Brushy Canyon group		34	34N	3W	MD	Copper mine; adit, 300 ft.; prominent gossan. (Aubury, L. E. 05, p. 92; 08, p. 102; Averill, C. V. 39, p. 178; Brown, G. C. 16a, p. 763; Tucker, W. B. 24a, p. 428; 26, p. 146.)
*22	C	Bully Cove Co.	E. J. McLaggan, Winthrop, Calif. (1914)	Approx.	34N	3W	MD	Copper mine; also silver.

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Number	Class by production	Name of deposit	Name of owner or operator	Location: Sec.	Location: T.	Location: R.	Location: B. & M.	Remarks and references
23	A	Bully Hill (includes Delamar, Northern Light, Shasta Zinc & Copper); see also Rising Star	California Zinc Co., (Glidden Co.), 11001 Madison Ave., Cleveland, Ohio; E. L. Ralston, gen. mgr., Box 538, Redding, Calif. (1942)	15, 16, 21, 22, 28	34N	3W	MD	Zinc mine (sphalerite); also copper (chalcopyrite), lead (galena), silver, gold, pyrite; produced 1902-10, 1915-18, 1920-22, 1924-27. (Aubury, L. E. 05, pp. 34, 60, 75; 08, pp. 78-83, 106; Averill, C. V. 39, pp. 126, 174, 178; Brown, G. C. 16a, pp. 758, 759, 763, 774, 806, 809; Crawford, J. J. 94, p. 377; 96, pp. 61, 610; Diller, J. S. 03, pp. 126-130; Fairbanks, H. W. 93, p. 32; Laizure, C. McK 21, p. 519; Tucker, W. B. 22, pp. 43, 410-411; 26, pp. 147, 213.)
24	D	California Iron & Steel Co.		26	34N	4W	MD	(Aubury, L. E. 05, map p. 48.)
		California Zinc Co.: see Bully Hill						
25	D?	Calumet		10	32N	5W	MD	Gold mine.
26	D	Canyon Creek	E. Baker, Los Gatos, Calif. (1943)	4	36N	1W	MD	Copper mine; traces of copper mineralization; north of copper belt. (Averill, C. V. 39, pp. 126, 178.)
27	D	Canyon group		2	33N	2W	MD	Adit, 70 ft. (Aubury, L. E. 08, p. 111.)
		Carlile: see Last Piece						
°28	D?	Chalcosa		14, 15	33N	6W	MD	
29	C	Chance		21	34N	3W	MD	Copper mine; ore similar to Bully Hill; 80 acres, patented; mined for silver in 1880's; small amount of development. (Aubury, L. E. 02a, p. 9; Averill, C. V. 39, p. 178; Brown, G. C. 16a, p. 764; McGregor, A. 90b, p. 638.)
30	D	Chattadown group		6	36N	2W	MD	Northeast of belt. (Aubury, L. E. 05, p. 93; 08, p. 107.)
31	D	Clover Creek Copper Lease	R. W. Byers, Los Gatos, Calif. (1944)	32	33N	1W	MD	Copper mine; east of copper belt; 240 acres, patented; adit, 80 ft.; drift; on 7-ft. vein. (Averill, C. V. 39, p. 179; Laizure, C. McK 21, p. 516.)
°32	C	Colma group	M. E. Dittmar, San Francisco, Calif. (1925)	6 31	33N 34N	5W 5W	MD MD	Copper mine; developed through No. 5 adit of Uncle Sam mine in hope of picking up extension of Mammoth ore body; adit, 3000 ft. in 1924. (Averill, C. V. 39, p. 179; Tucker, W. B. 23a, p. 57; 24a, p. 432; 26, p. 148.)
		Complex: see Iron Mountain mine						

33	D	Congress group		4	33N	2W	MD	Copper mine; adits, 430 ft. (Aubury, L. E. 02a, p. 9; 08, p. 111; Averill, C. V. 39, p. 179.)
34	D	Consolidated Copper Co.		4	36N	1W	MD	Northeast of copper belt.
35	C	Copley		32	33N	5W	MD	Gold mine; gossan worked for gold; sulphide vein, 4 ft.; adit, 310 ft.; drift, 60 ft.; stope 60 ft. (Aubury, L. E. 02a, p. 9; Averill, C. V. 39, p. 179; Brown, G. C. 16a, p. 783; Crawford, J. J. 96, p. 352.)
		Copper City: see Baxter-Winthrop						
°36	D	Copper Crest group	U. S. Smelt. Ref. & Mining Co., Salt Lake City, Utah (1944)	32	34N	5W	MD	Abandoned? (Aubury, L. E. 05, p. 114.)
°37	D	Copper King group	U. S. Smelt. Ref. & Mining Co., Salt Lake City, Utah (1944)	8	34N	3W	MD	Abandoned? (Aubury, L. E. 02a, p. 9.)
38	C	Cortez		1[illegible]	33N	2W	MD	Gold mine; some gold produced; 170-ft. adit; near Afterthought. (Averill, C. V. 39, p. 179; Brown, G. C. 16a, p. 783; Crawford, J. J. 94, p. 70; 96, p. 352.)
39	D	Cowboy		4	33N	2W	MD	Adits, 200 ft.; near Afterthought. (Aubury, L. E. 05, p. 94; 02a, p. 9; 08, p. 108.)
°40	D	Crystal group	Crystal Copper Mining Co., Central Valley, Calif. (1944)	11	33N	6W	MD	Copper mine; 200 ft. development. (Aubury, L. E. 08, p. 113; Averill, C. V. 39, p. 179; Brown, G. C. 16a, p. 764; Tucker, W. B. 24a, p. 434; 26, p. 151.)
		Cyanide: see Populist						
*41	C	Davidson	L. A. Davidson, Ingot, Calif. (1913)	Approx.	33N	2W	MD	Gold mine; also lead, silver.
°42	D	De Dallis (Doedollis)		34	34N	3W	MD	Copper mine; 420 ft. workings. (Aubury, L. E. 05, p. 92; 02a, p. 9, 08, p. 102; Averill, C. V. 39, p. 179; Brown, G. C. 16a, pp. 764-765.)
		Deep Pit: see Peterson						
		Delamar (part of Bully Hill, which see)		22	34N	3W	MD	Once considered a north extension of Bully Hill; produced 1905-08. (Aubury, L. E. 05, map p. 48; Diller, J. S. 03, pp. 126-130; Reinholt, O. H. 08, p. 678.)
°43	D?	Diamond Fraction		23	33N	6W	MD	
°44	D?	Dittmar		4	33N	5W	MD	Copper mine.
		Doedollis: see De Dallis						
		Dome: see Blue Jay						

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Number	Class by production	Name of deposit	Name of owner or operator	Location				Remarks and references
				Sec.	T.	R.	B. & M.	
45	C	Donkey	Afterthought Zinc Mining Co., Ingot, Calif. (1944)	11	33N	2W	MD	Copper-zinc mine; also lead, silver, gold; an early discovery; produced 1913; promise as a zinc producer modified by metallurgical difficulties with ore. (Aubury, L. E. 05, p. 93; 02a, p. 9; 08, pp. 105-106; Averill, C. V. 39, p. 180; Lang, H. 99, p. 562; Tucker, W. B. 24a, p. 432; 26, p. 148.)
°46	D	Dozier	Dozier & Sandholt, 1313 Placer St., Redding, Calif. (1939)	13	33N	5W	MD	Copper mine, 320 acres patented; prominent gossan; 120 ft. adit, does not reach sulphide zone. (Averill, C. V. 39, p. 180; Laizure, C. McK 21, p. 517.)
47	D	Dunn Bros.		18, 19 13, 24	32N 32N	5W 6W	MD MD	Abandoned. (Aubury, L. E. 05, map p. 48.)
48	B?	Early Bird		Approx. 10	33N	6W	MD	Copper mine.
°49	D?	Eastern		23	33N	6W	MD	
°50	D?	Elizabeth		3, 10 11	32N	6W	MD	Copper mine.
51	D	Endless Chain and Missing Link		24	34N	4W	MD	Two 30-ft. adits. (Aubury, L. E. 08, p. 113.)
52	C	Evening Star	Evening Star Mining Co., Whitehouse, Calif. (1916)	3, 4	32N	5W	MD	Gold mine; also silver. (Averill, C. V. 33, p. 40, pl. 2; 39, p. 180.)
°53	D	Ferguson and Limbough		4	33N	5W	MD	Adits, 165 ft. (Aubury, L. E. 05, p. 90; 08, p. 98.)
54	D	Fish	M. & A. W. Hardenbrook, Redding, Calif. (1944)	27, 34	33N	4W	MD	Patented. (Aubury, L. E. 02a, p. 9.)
55	D	Florence		18	30N	7W	MD	Gold prospect; southwest of copper belt. (Aubury, L. E. 02a, p. 5; Averill, C. V. 39, p. 180.)
°56	D	Fluke and Abbott		20	34N	3W	MD	Native copper; adit, 25 ft. (Aubury, L. E. 02a, p. 9.)
		Franklin: see Milkmaid and Franklin						
57	B?	Friday-Lowden (-Louden) group	U.S. Smelt. Ref. & Mining Co., Salt Lake City, Utah (1945)	5, 6	33N	5W	MD	Copper mine (chalcopyrite); also pyrite, quartz, and barite gangue; worked in early days for gold; references cover independent existence. (Aubury, L. E. 05, p. 86; 02a, p. 9; 08, pp. 94-95; Averill, C. V. 39, p. 181; Brown, G. C. 16a, p. 765; Graton, L. C. 10, pp. 90-91.)

58	C?	Galvin (Sugar Loaf)	State of California (1944)	26	33N	6W	MD	Copper mine; over 4,000 ft. of workings; no definite ore body found. (Aubury, L. E. 02, p. 81; 02a, p. 10; 08, p. 84; Averill, C. V. 39, p. 188; Graton, L. C. 10, p. 90.)
59	C?	Ganim Gellispie: see Gillispie	Ganim Gold Mines Co., Redding, Calif. (1932)	5, 8	32N	6W	MD	Gold mine; also copper (chalcopyrite), zinc (sphalerite), lead (galena), and pyrite, in talc. (Averill, C. V. 33, p. 26.)
°60	D	Gillispie (Gellispie); see also Mammoth		4	33N	5W	MD	(Aubury, L. E. 05, map p. 48.)
°61	D	Giant Consolidated (Motion Creek group)		19 24	33N 33N	5W 6W	MD	Copper mine; adit, 310 ft.; open cuts; 440 acres patented. (Aubury, L. E. 05, p. 81; 02a, p. 9; 08, pp. 85, 114; Averill, C. V. 39, p. 181; Brown, G. C. 16a, p. 765.)
62	D	Gleaves group		26	34N	4W	MD	Copper mine. (Aubury, L. E. 05, map p. 48; Tucker, W. B. 26, p. 139.)
63	D	Gold Belt group		4	33N	2W	MD	Copper mine; shaft, 60 ft. (Aubury, L. E. 08, p. 111; Averill, C. V. 39 p. 181; Brown, G. C. 16, p. 765.)
		Gold Mines: possibly Uncle Sam, which see		6 31 1	33N 34N 33N	5W 5W 6W	MD	(Aubury, L. E. 05, map p. 48.)
64	B	Golinsky (Golinski, Little Backbone) Grab: see Stowell	U.S. Government (1946) Golinsky Copper Co., c/o W. D. Tillotson, Box 68, Redding, Calif. (1939)	28	34N	5W	MD	Copper mine, with gold, silver, lead; produced 1907, 1932-33, 1935, 1937. (Averill, C. V. 39, p. 181.)
65	D	Graham group (Shasta Belmont)	U.S. Government (1944)	24	34N	4W	MD	Copper mine (chalcopyrite and chalcocite in bunches in andesite); three cars 7% Cu ore shipped in 1915; two adits, 350 ft. and 225 ft. on an E-striking fracture. (Aubury, L. E. 08, p. 113; Averill, C. V. 39, p. 187; Tucker, W. B. 23b, p. 92; 24a, p. 445; 26, p. 160.)
66	B	Graves group (Summit)	U.S. Smelt. Ref. & Mining Co., Salt Lake City, Utah (1945)?	30	34N	5W	MD	Copper mine; ore body over 30 ft. wide in places; three adits, one 400 ft.; one 350 ft. raise; ore was trammed to Kennett via Sutro mine. (Aubury, L. E. 02a, p. 9; 08, p. 97; Averill, C. V. 39, p. 188; Brown, G. C. 16a, p. 773; Tucker, W. B. 24a, p. 447; 26, p. 162.)
°67	D	Great Verde (Vulcan)	U.S. Smelt. Ref. & Mining Co., Salt Lake City, Utah (1944)	11, 12	33N	6W	MD	Copper mine just north of Balaklala; much exploration but only low-grade ore developed. (Aubury, L. E. 08, p. 98; Averill, C. V. 39, p. 182; Brown, G. C. 16a, p. 786.)
68	B	Greenhorn (Warren Bros., Willow Creek Mines, Inc.)	Greenhorn Mining Co., 2135 Sacramento St., Piedmont, Calif. (1944)	5, 6 31, 32	32N 33N	7W 7W	MD MD	Copper mine (chalcopyrite, pyrrhotite), with pyrite, gold, silver, lead; produced 1915-17, 1928-30. (Averill, C. V. 39, p. 182.)
69	D	Gregory and Whalen (Oom Paul)		25	35N	5W	MD	Undeveloped gossan showing; north of copper belt. (Aubury, L. E. 05, p. 90; 08, p. 100.)

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Number	Class by production	Name of deposit	Name of owner or operator	Location Sec.	T.	R.	B. & M.	Remarks and references
70	D	Haley group (Minnie Haley)		24	34N	4W	MD	Copper mine. (Averill, C. V. 39, p. 185.)
71	C?	Hardtack		Approx. 26	33N	6W	MD	Copper mine, between King Copper and Sugarloaf mines. (Graton, L. C. 10, map p. 72.)
72	D	Hartford group		24	35N	2W	MD	Copper mine, northeast of copper belt. Over 500 ft. of workings. (Aubury, L. E. 05, p. 93; 08, p. 108; Averill, C. V. 39, p. 182; Brown, G. C. 16a, p. 766.)
73	C	Hobo (Hoboe)	E. H. Blagrave, French Gulch, Calif. (1940)	17	33N	7W	MD	Gold mine; also silver. (Averill, C. V. 39, p. 182.)
°74	D?	Holcomb Cons.		11	33N	6W	MD	
75	A	Hornet (see also Iron Mountain mine)	Mountain Copper Co., Ltd., San Francisco, Calif. (1944)	35	33N	6W	MD	Pyrite mine, with copper and zinc; Cu, 0.7%; S. 45-48%. (Averill, C. V. 39, p. 182; Laizure, C. McK 21, pp. 525-526; O'Brien, C. 43, p. 327.)
°76	D	Horse Mountain group		18	34N	3W	MD	Native copper. (Aubury, L. E. 08, p. 112.)
°77	D	Hotchkiss		34	34N	3W	MD	(Aubury, L. E. 02a, p. 9.)
78	C	Hot Head	R. Pomeroy, Hayward, Calif. (1935)	27?	32N	6W	MD	Gold mine; also silver.
		Hubbard: see Kingsbury and Hubbard						
°79	D	Independence group		14	34N	3W	MD	(Aubury, L. E. 02a, p. 9.)
80	C	Indiana and Last Chance	First National Copper Co., San Francisco, Calif. (1944)	29	33N	5W	MD	Copper-gold mine; sulphide ore with some high-grade oxides; small producer 1916; several hundred feet workings. (Aubury, L. E. 02a, p. 9; Averill, C. V. 39, p. 183; Brown, G. C. 16a, p. 766; Crawford, J. J. 96, p. 359.)
		Ingersoll: see Peerless						
81	A	Iron Mountain mine (Complex, Mountain Copper, No. 8, Old Mine; see also Hornet)	Mountain Copper Co., Ltd., 351 California St., San Francisco, Calif. (1944)	34, 35	33N	6W	MD	Gold (pyrite, gossan), copper (chalcopyrite), zinc (sphalerite), iron; produced 1896-99, 1900, 1902-20, 1922-34, 1940-44. (Aubury, L. E. 08, pp. 70-78; Averill, C. V. 34a, p. 305; 39, p. 185; Crawford, J. J 94, p. 377; Fairbanks, H. W. 93, p. 46; Irelan, W. 88, p. 566; Kett, W. F. 47; Tucker, W. B. 24a, p. 423; 26, pp. 142, 154-160.)
°82	D	Jaegel (Bismarck)		3	33N	4W	MD	(Aubury, L. E. 05, p. 95; 02a, p. 9; 08, pp. 109, 112; Tucker, W. B. 26, map p. 138.)

		Janice: see Benson						
83	D	Jennings	J. J. Jennings, Baird, Calif. (1925)	7, 8	35N	3W	MD	Iron mine. (Tucker, W. B. 26, p. 190.)
°84	D	Jumping Jack	S. P. Land Co. (1944)	24, 25	33N	6W	MD	Copper mine; adit, 400 ft. (Aubury, L. E. 05, p. 81; 02a, p. 9; 08, p. 85; Averill, C. V. 39, p. 183; Brown, G. C. 16a, p. 767.)
		Kane: see Keane						
85	D	Kane and Wilbur group		24	34N	4W	MD	Deposit of iron (magnetite), nickel (pyrrhotite), copper (chalcopyrite), pyrite; vein 6-10 ft. wide; 40-ft. shaft, 250 ft. of drift. (Tucker, W. B. 23b, pp. 92-93.)
86	D	Keane (Kane)	H. J. Keane, Oakland, Calif. (1925)	4	36N	3W	MD	Copper mine; located 1925; 7 adits 20-135 ft.; narrow veins in lava; north of copper belt. (Averill, C. V. 39, p. 183; Tucker, W. B. 26, pp. 149-150.)
°87	D	Keith group (Shasta May Blossom)	U. S. Government (1944)	14, 15	34N	3W	MD	Copper mine; contact of "rhyolite and shale;" pyrite with some chalcopyrite; last work was drilling program in 1921—results unsatisfactory; only small ore bodies developed; seven adits, raises, etc., aggregating over 2,000 ft. (Aubury, L. E. 05, p. 92; 02a, p. 9; 08, p. 100; Averill, C. V. 39, p. 187; Brown, G. C. 16a, p. 772; Tucker, W. B. 23b, p. 91; 24a, p. 446; 26, pp. 139, 161.)
88	A	Keystone	U.S. Smelt. Ref. & Mining Co., Salt Lake City, Utah (1945)	14	33N	6W	MD	Copper mine (chalcopyrite); also gold and silver; produced 1924-25. (Aubury, L. E. 05, p. 90; 08, p. 100; Averill, C. V. 39, p. 183; Tucker, W. B. 23, p. 8; 24a, p. 435.)
°89	D	King	State of California (1944)	35	33N	6W	MD	Copper mine; no development; formerly part of Pittsburgh & Mt. Shasta Mining Co. property; deeded in 1935 to State. (Aubury, L. E. 05, p. 81; 02a, p. 9; 08, p. 85.)
90	B?	King Copper group	S. P. Land Co. and State of California (1944)	23, 24 25, 26	33N	6W	MD	Copper mine; formerly owned by Trinity Copper Co.; low-grade ore body; 1,000 ft. developed. (Aubury, L. E. 05, p. 81; 02a, p. 9; 08, p. 84; Averill, C. V. 39, p. 183; Graton, L. C. 10, p. 90; Tucker, W. B. 24a, p. 447; 26, p. 162.)
91	C	Kingsbury & Hubbard	A. N. Kingsbury (1922)	20	31N	6W	MD	Silver mine; also gold.
92	D	Kosk Creek (Kosh)	W. Murray (1925)	23	37N	1W	MD	Copper mine; native Cu in basalt; slightly developed; northeast of copper belt. (Aubury, L. E. 05, p. 93; 08, p. 108; Averill, C. V. 39, p. 183; Brown, G. C. 16a, p. 767; Tucker, W. B. 24a, p. 433; 26, p. 150.)
°93	D	Lady Smith		22	34N	3W	MD	(Aubury, L. E. 02a, p. 9.)
		Last Chance: see Indiana and Last Chance						
°94	D?	Last Piece (Carlile, Milo, Triangle)	Shasta Copper Exploration Co., Vacaville, Calif. (1944)	13	33N	6W	MD	
°95	D?	Lawson Butte Cons.		24, 25	33N	6W	MD	

SHASTA COUNTY—Continued

Number	Class by production	Name of deposit	Name of owner or operator	Location				Remarks and references
				Sec.	T.	R.	B. & M.	
		Limbough: see Ferguson and Limbough						
		Little Backbone: see Golinsky						
°96	C	Little Nellie (Alleghany, Bennington)	State of California (1944)	27, 35	33N	6W	MD	Gold mine; quartz veins; also a little copper (chalcopyrite); also pyrite; very close to Iron Mountain. (Averill, C. V. 39, p. 183.)
°97	D?	Lone Hand		24	33N	6W	MD	
98	C?	Lone Star		21?	33N	6W	MD	Copper mine. (Graton, L. C. 10, map p. 72.)
99	C	Loraine		7, 18	33N	5W	MD	Copper mine; adit, 425 ft. on ore body. (Aubury, L. E. 05, p. 81; 02a, p. 9; 08, p. 87; Averill, C. V. 39, p. 184; Brown, G. C. 16a, p. 767.)
		Lost Desert: see Shasta King						
100	A	Mammoth (Anderson, Mayflower, Sheridan, Gillispie)	U.S. Smelt. Ref. & Mining Co., Salt Lake City, Utah (1943)	1, 12 32, 33	33N 34N	6W 5W	MD MD	Copper (chalcopyrite), zinc (sphalerite), gold, with pyrite; produced 1905-20, 1922-25. (Aubury, L. E. 05, p. 87; 08, pp. 95-97; Averill, C. V. 39, p. 184; Brown, G. C. 16a, pp. 758, 767; Crawford, J. J. 94, p. 252; 96, p. 361; Hodson, W. G. 93, p. 397; Irelan, W. J. 88, p. 568; Tucker, W. B. 22, pp. 206, 296; 24a, pp. 434-435; 26, p. 150.)
*101	C	Mariana Marsicano	Mariana Marsicano Mining Co., Ono, Calif. (1913)	Approx.	31N	7W	MD	Gold mine; also silver.
°102	D	Marshall and Walters		14, 15	33N	6W	MD	Copper mine; just west of Stowell; 400-ft. adit. (Aubury, L. E. 05, p. 82; 02a, p. 9; 08, p. 85; Averill, C. V. 39, p. 184; Brown, G. C. 16a, p. 769.)
		Mayflower: see Mammoth						
°103	D	McCloves		10	34N	3W	MD	Copper mine. (Tucker, W. B. 26, p. 139.)
		McClure: see Pioneer						
104	D	Memorial		15, 22	33N	4W	MD	Copper mine. (Aubury, L. E. 05, p. 95; 02a, p. 9; Tucker, W. B. 26, p. 139.)
105	C?	Michigan group	A. Anderson, Sacramento, Calif. (1944)	16	34N	3W	MD	Copper. (Aubury, L. E. 05, p. 95; 08, p. 109; Tucker, W. B. 26, p. 139.)
106	C	Milkmaid & Franklin	J. H. Scott, French Gulch, Calif. (1935)	9, 16	33N	7W	MD	Gold mine. (Averill, C. V. 39, p. 185.)

		Milo: see Last Piece						
°107	D	Mineral Mountain	Mountain Copper Co., Ltd.?	13	32N	6W	MD	Copper mine; adit, 300 ft. (Aubury, L. E. 05, p. 80; 08, p. 84; Averill, C. V. 39, p. 185; Brown, G. C. 16a, p. 769.)
		Miners group: see Brunswick						
		Minnie Haley: see Haley						
		Missing Link: see Endless Chain & Missing Link						
°108	D	Mooer Small		32	34N	3W	MD	Copper mine. (Aubury, L. E. 05, map p. 48; Tucker, W. B. 26, p. 139.)
°109	D	Mooer-Welch		28	34N	3W	MD	Copper mine. (Tucker W. B. 26, p. 139.)
°110	D	Morris		10	34N	3W	MD	Copper mine; adits, 400 and 80 ft. (Averill, C. V. 39, p. 185; Brown, G. C. 16a, p. 769.)
		Motion Creek group: see Giant Cons., successors						
		Mt. Shasta: see Pittsburgh and Mt. Shasta						
		Mountain Copper: see Iron Mountain mine						
111	C?	Mountain Monarch		28, 33	32N	6W	MD	Copper mine; adit, 700 ft. failed to reach ore body which is 5 ft. wide on surface. (Averill, C. V. 39, p. 185; Brown, G. C. 16a, p. 770; Tucker, W. B. 24a, p. 445; 26, p. 160.)
112	C	Niagara	Niagara Summit Mining Co., French Gulch, Calif. (1936)	6, 7, 8 17, 18	33N	7W	MD	Gold mine, with silver, lead. (Averill, C. V. 39, p. 186.)
		No. 8: see Iron Mountain mine						
		Northern Calif. Investment Co.: see Black Diamond group						
		Northern Light (part of Bully Hill, which see)		16, 21	34N	3W	MD	(Aubury, L. E. 08, p. 110; McGregor, A. 90b, p. 638.)
°113	D	Ohio	State of California (1944)	12	33N	6W	MD	Copper mine. Some pyrite ore developed; 120 acres patented; over 500 ft. adits. (Aubury, L. E. 02a, p. 9; Averill, C. V. 39, p. 186; Brown, G. C. 16a, p. 770; Tucker, W. B. 24a, p. 445.)
		Old Mine: see Iron Mountain mine						
		Oom Paul: see Gregory and Whalen						
°114	D	Oregon Cons. (United and Copper Queen)		13, 14	33N	6W	MD	Copper mine; adits, 1500 ft. (Aubury, L. E. 08, p. 113; Averill, C. V. 39, p. 186; Brown, G. C. 16a, p. 770.)

SHASTA COUNTY—Continued

Number	Class by production	Name of deposit	Name of owner or operator	Location				Remarks and references
				Sec.	T.	R.	B. & M.	
*115		Pacific Mineral Corp.						Constructed a plant to treat flue dust at Kennett in 1926; produced zinc and copper. (Averill, C. V. 39, p. 186; Tucker, W. B. 26, p. 216.)
*116	C	Parker Metal Mining Co.	L. C. Parker, Redding, Calif. (1917)	Approx.	32N	6W	MD	Silver mine.
		Peck (an early-day name for Afterthought, which see)						
°117	D	Peerless (Ingersoll)		25, 36	33N	6W	MD	Copper mine; adits, 180, 165, 135 ft. (Aubury, L. E. 08, p. 114; Averill, C. V. 39, p. 183; Brown, G. C. 16a, p. 766.)
118	D	Peterson (Deep Pit)	T. H. Peterson, Heroult, Calif. (1929)	36	34N	4W	MD	Paint mine; iron gossan with pyrite and chalcopyrite.
119	C	Philadelphia & Roosevelt	Vogt & Vogt, French Gulch, Calif. (1935)	17	33N	7W	MD	Gold mine, with silver, lead. (Averill, C. V. 39, p. 186.)
°120	D	Pioneer (McClure)		10, 15 16	34N	3W	MD	Copper mine; just northeast of Bully Hill; 160 acres patented; 500-ft. adit. (Aubury, L. E. 08, p. 110; Averill, C. V. 39, p. 184; Brown, G. C. 16a, p. 769; Tucker, W. B. 24a, p. 438; 26, p. 154.)
121	C	Pit River	S. P. Land Co.	25	34N	3W	MD	Copper mine; some ore shipped; 500-ft. adit. (Averill, C. V. 39, p. 186 Brown, G. C. 16a, p. 770.)
122	C	Pittsburgh & Mt. Shasta (Mt. Shasta)	T. V. Scott, Pittsburgh, Pa. (1918)	33, 34	32N	6W	MD	Gold mine; also silver. (Averill, C. V. 39, p. 185.)
°123	D	Polkingham	State of California (1944)	11	33N	2W	MD	Copper mine; shaft, 120 ft. (Aubury, L. E. 08, p. 111; Averill, C. V. 39, p. 186; Brown, G. C. 16a, p. 771.)
°124	D	Popejoy	S. P. Land Co.	25	34N	3W	MD	Copper mine; short adits. (Aubury, L. E. 02a, p. 9; Averill, C. V. 39, p. 186; Brown, G. C. 16a, p. 771.)
°125	D?	Populist (Cyanide)		1	33N	6W	MD	
°126	D?	Pot Latch Cons.		11, 12	33N	6W	MD	
127	D?	Quartz Hill		10, 11	32N	5W	MD	Copper mine.
°128	D	Red Rock	U. S. Smelt. Ref. & Mining Co., Salt Lake City, Utah?	3	33N	5W	MD	(Aubury, L. E. 02a, p. 9.)

129	C?	Reid	B. W. & M. L. Shelton, San Francisco, Calif. (1944)	3	32N	5W	MD	Gold mine. (Averill, C. V. 39, p. 187.)
130	D	Reno		20	34N	4W	MD	Prospect. (Aubury, L. E. 08, p. 113.)
°131	D	Reynolds		10	33N	6W	MD	Just north of Balaklala. (Aubury, L. E. 08, p. 114.)
132	A	Rising Star (Anchor Lode); see also Bully Hill	California Zinc Co., Oakland, Calif. (1944)	21, 28	34N	3W	MD	Zinc, gold, silver, lead. Production included with Bully Hill: 1924, 1927. (Averill, C. V. 39, p. 174; Diller, J. S. 06, p. 13, map; Tucker, W. B. 22, pp. 411-413; 26, pp. 147, 148.)
		Roosevelt: see Philadelphia and Roosevelt						
°133	D	Roseman		3 34	33N 34N	4W 4W	MD MD	Copper mine. Adits, 700 ft.; shafts, 200 ft. (Aubury, L. E. 08, p. 109; Averill, C. V. 39, p. 187; Brown, G. C. 16a, p. 771.)
134	D	St. John	Mrs. C. E. Eilers, Ingot, Calif. (1925)	30	34N	1W	MD	Zinc mine—sphalerite; with some galena, chalcopyrite. (Tucker, W. B. 26, p. 216.)
*135	C	Salinger	H. Salinger, San Francisco, Calif. (1921)	Approx.	33N	7W	MD	Lead-silver mine, with gold.
°136	D?	Sallee Townsite		22	34N	3W	MD	
°137	D	Sanders	California Zinc Co., Oakland, Calif. (1944)	21	34N	3W	MD	Part of Arps group; adjoins Rising Star. (Aubury, L. E. 08, p. 112.)
138	D	Schmidt		23	37N	1W	MD	A prospect northeast of copper belt. (Aubury, L. E. 05, p. 93; 08, p. 107.)
139	D	Senator group		2	33N	4W	MD	Adits, 450 ft. (Aubury, L. E. 08, p. 112.)
		Shasta Belmont: see Graham group						
°140	D	Shasta Kennett	Either U. S. Smelt. Ref. & Mining Co., Salt Lake City, Utah (W½); or U. S. Government (E½)	35	34N	5W	MD	Copper mine; adit, 450 ft.; workings, in all, 700 ft. (Aubury, L. E. 08, p. 114.)
141	A	Shasta King (Lost Desert, Trinity)	Gray Eagle Copper Co., Redding, Calif. (1944)	11, 12	33N	6W	MD	Copper (chalcopyrite), gold, silver, pyrite; total workings 15,000 ft. (Aubury, L. E. 08, pp. 87-88; Averill, C. V. 39, p. 187; Tucker, W. B. 24a, pp. 445-446.)
		Shasta May Blossom: see Keith group						
°142	D	Shasta National Copper Co.		18, 19 20	34N	5W	MD	Copper mine, just north of Mammoth; several adits. (Averill, C. V. 39, p. 188; Tucker, W. B. 24a, pp. 446-447; 26, p. 161.)
		Shasta Zinc and Copper Co.: see Bully Hill						
		Sheridan: see Mammoth						

SHASTA COUNTY—Continued

Number	Class by production	Name of deposit	Name of owner or operator	Location Sec.	T.	R.	B. & M.	Remarks and references
°143	D?	Skookum Cons.		11	33N	6W	MD	
°144	D	Slaughter group		26	34N	3W	MD	Adit, 30 ft. (Aubury, L. E. 08, p. 112.)
*145	C	Small Mines	French & Metcalf (1914)					Gold mine; also silver.
*146	C	Small Quartz	G. W. Garwood, French Gulch, Calif. (1918)	Approx.	33N	7W	MD	Gold mine; also silver.
°147	C	Spread Eagle	U.S. Smelt. Ref. & Mining Co., Salt Lake City, Utah (1938)	13	33N	6W	MD	Copper mine; workings aggregate 3,000 ft.; exhaustively prospected, but little ore found. (Aubury, L. E. 05, p. 82; 08, p. 85; Averill, C. V. 39, p. 188; Brown, G. C. 16a, p. 772; Tucker, W. B. 24a, p. 436; 26, p. 152.)
°148	D?	Statesman		1	33N	6W	MD	
°149	D	Stevenson	U.S. Smelt. Ref. & Mining Co., Salt Lake City, Utah (1944)	14	33N	6W	MD	Copper mine. (Aubury, L. E. 02a, p. 9; Averill, C. V. 39, p. 188; Brown, G. C. 16a, p. 772.)
°150	B?	Stowell (Grab, Webster)	U.S. Smelt. Ref. & Mining Co., Salt Lake City, Utah (1945)	14	33N	6W	MD	Copper mine; also gold, silver; references apply to early history. (Aubury, L. E. 08, p. 85; Averill, C. V. 39, p. 188; Brown, G. C. 16a, p. 772; Crawford, J. J. 96, pp. 364-365; McGregor, A. 90b, p. 633; Tucker, W. B. 24a, p. 436.)
		Sugar Loaf: see Galvin						
°151	D?	Sulphide		12	33N	6W	MD	
°152	D	Sulphide		16	32N	6W	MD	Copper mine, south of copper belt. (Averill, C. V. 39, p. 188; Brown, G. C. 16a, p. 773.)
		Summit: see Graves group						
153	D	Surprise		19 24	32N 32N	5W 6W	MD MD	Gold mine. (Aubury, L. E. 05, map p. 48; Averill, C. V. 39, p. 189.)
154	A	Sutro	U.S. Smelt. Ref. & Mining Co., Salt Lake City, Utah (1945)	29	34N	5W	MD	Copper mine (chalcopyrite), and pyrite; produced 1924-25; separate mine, but part of Mammoth group. (Averill, C. V. 39, p. 189.)
*155	C	Taifar	L. L. Taifar, Bella Vista, Calif. (1918)	Approx.	33N	2W	MD	Silver-copper mine.
°156	D	Tamarack		21	34N	3W	MD	Abandoned.? (Aubury, L. E. 05, map p. 48.)
*157	C	Taylor	G. C. Taylor, Redding, Calif. (1918)	Approx.	33N	2W	MD	Gold-copper mine; also silver.

°158	D	Texas		33	33N	5W	MD	Gold mine.
159	D	Thompson (American Girl?)	H. E. Schoonover, Summit City, Calif. (1944)	34	33N	4W	MD	Gold-copper mine; chalcopyrite in quartz; 480 acres patented. (Aubury, L. E. 08, p. 112; Averill, C. V. 39, pp. 153-154, 189.)
		Triangle: see Last Piece						
		Trinity: see Shasta King						
160	C	Uncle Sam group (Gold Mines?)	Dakin Co. and Alice R. Goodfellow estate, Redding, Calif. (1944)	1 6	33N 33N	6W 5W	MD MD	Gold mine, also silver; operated 1909, 1915, 1916; produced more than $1,000,000 before 1913. (Averill, C. V. 39, pp. 154, 189; 33, pp. 54-55; Tucker, W. B. 23a, pp. 56-57.)
		United and Copper Queen: see Oregon Cons.						
°161	D?	United Copper		23	33N	6W	MD	Copper mine. Copper mine. (Averill, C. V. 39, p. 189.)
		U.S. Smelt. Ref. & Mining Co.: see Mammoth						
°162	D	Varsity group		13, 14 24	34N	5W	MD	North of copper belt. (Aubury, L. E. 08, p. 114.)
		Vulcan: see Great Verde						
163	C	Walker	I. J. Finberg, Redding, Calif. (1941)	3, 4 10	32N	5W	MD	Gold-copper mine; also silver. (Averill, C. V. 39, pp. 155, 190.)
		Walters: see Marshall and Walters						
		Warren Bros.: see Greenhorn						
164	C	Washington	J. H. Scott Co., San Francisco, Calif. (1942)	16	33N	7W	MD	Gold mine; also silver, lead. (Averill, C. V. 39, p. 190.)
		Webster: see Stowell		14	33N	6W	MD	
		Welch: see Mooer-Welch						
		Whalen: see Gregory & Whalen						
		Wilbur: see Kane & Wilbur						
*165	C	Wild Cat	C. H. Harrington, Kennett, Calif. (1912)					Silver mine.
		Willow Creek Mines, Inc.: see Greenhorn						

SHASTA COUNTY—Continued

Number	Class by production	Name of deposit	Name of owner or operator	Location Sec.	T.	R.	B. & M.	Remarks and references
		Windy Camp: see Balaklala						
		Winthrop: see Baxter-Winthrop						
166	C	Woodrow Wilson		4	33N	2W	MD	Copper mine (chalcopyrite); also zinc (sphalerite), lead (galena), and pyrite; just west of Afterthought; two vein systems—one high in lead, the other like Afterthought; three adits aggregating 1,000 ft.; active before 1923. (Averill, C. V. 39, p. 190; Tucker, W. B. 23a, p. 56; 24a, p. 447; 26, p. 162.)
		Yankee Jack: see Yankee John						
167	C	Yankee John (Yankee Jack)	W. L. Hill, Redding, Calif. (1941)	17	31N	5W	MD	Silver-gold mine, also lead. (Averill, C. V. 39, p. 190; 33, p. 57.)
°168	D	Ydalpom	A. Anderson, Sacramento, Calif. (1944)	16	34N	3W	MD	Copper mine. (Aubury, L. E. 05, p. 96; 08, p. 111.)

* Not shown on map because of lack of definite location.
° Not shown on map because of crowded condition.

SISKIYOU COUNTY

Number	Class by production	Name of deposit	Name of owner or operator	Location				Remarks and references
				Sec.	T.	R.	B. & M.	
1	D	Ames	A. Ames, Happy Camp, Calif. (1934)	31	15N	7E	H	Copper mine; gossan outcrops; assessment work. (Averill, C. V. 35, p. 271; Logan, C. A. 25a, p. 427.)
2	D	August Flower		1	41N	8W	MD	Irregular bodies in serpentine. (Aubury, L. E. 05, p. 105; 08, p. 124.)
3	D	Barnum Bros. (Copper Mountain)		36	14N	5E	H	Copper mine. Active 1919, 1925; adit; several hundred feet of workings. (Averill, C. V. 35, p. 271; Logan, C. A. 25a, p. 427; O'Brien, J. C. 47, p. 424.)
4	D	Barton (Hetchell)	H. J. Barton estate, Yreka, Calif. (1944)	24	47N	11W	MD	Copper mine, on Horse Creek. (Averill, C. V. 35, p. 271; Logan, C. A. 25a, p. 427.)
5	D	Bathhurst		15	40N	9W	MD	NE. ¼ sec. 15, patented. (Aubury, L. E. 08, p. 127.)
6	D	Bear Mountain (Nelson)	F. Nelson, Trout Camp, Calif.	32	17N	5E	H	Copper mine. (Maxson, J. H. 33, p. 146.)
6A	D	Big Blue		36	40N	9W	MD	
7	C	Bloomfield		33	48N	11W	MD	Adits, 340, 180 ft.; 40-ft. ore zone parallels Blue Ledge vein. (Aubury, L. E. 08, p. 129; Stevens, H. J. 11, p. 673.)
		Blue Bell: see Copper Creek						
8	A	Blue Ledge	Compania Metalurgica Mexicana, New York, N.Y. (1944)	3 34	47N 48N	11W 11W	MD MD	Copper-zinc mine, with silver, gold, lead. Lenses of good copper-zinc ore and of low-grade pyrite ore, in sericite schist. Developed by adits. (Aubury, L. E. 05, p. 108; 08, p. 128; Averill, C. V. 35, p. 271; Brown, G. C. 16b, p. 817; Laizure, C. McK 21, p. 530; Logan, C. A. 26a, p. 375; Maxson, J. H. 33, p. 145; Neale, W. G. 27, p. 502; O'Brien, J. C. 47, p. 424; Shenon, P. J. 33, pp. 12-13; Stoval, D. H. 08, pp. 635-636; Tucker, W. B. 23, p. 8; Weed, W. H. 16, p. 228; 18, p. 633.)
9	D	Bonanza		27, 34	42N	8W	MD	Sulphides in quartz; shafts and adits. (Aubury, L. E. 08, p. 123.)
10	D	Bonanza group		21	47N	8W	MD	Sulphide ore 8-12 ft. thick.; 520 ft. of workings. (Aubury, L. E. 05, p. 107; 08, p. 126.)
		Boorse: see Efman & Boorse						
11	D	Bunnell		21	47N	8W	MD	Bonanza group. (Aubury, L. E. 05, p. 107; 08, p. 126.)
		Buzzard: see Buzzard Hill						
12	D?	Buzzard Hill (Buzzard)	Buzzard Hill Mine, Inc., Happy Camp, Calif. (1934)	4, 5	15N	7E	H	Copper-gold mine; pyrite body; also chalcopyrite and gold. (Averill, C. V. 35, pp. 272, 276.)

SISKIYOU COUNTY—Continued

Number	Class by production	Name of deposit	Name of owner or operator	Location Sec.	T.	R.	B. & M.	Remarks and references
13	C?	Chalco Copper Co. (Houston)	Gordon Jacobs, Hornbrook, Calif. (1944)	26	41N	7W	MD	Copper in quartz vein; shaft, 100 ft.; adit, 125 ft. (Rand, L. H. 31, p. 527.)
		Chalcopyrite: see Polar Bear						
14	D	Clear Creek (Davis)	Estate of Reeves Davis (1934)	12	15N	6E	H	Copper mine; large surface showings have been extensively prospected; no large bodies of commercial ore developed. (Aubury, L. E. 05, p. 109; 08, p. 132; Averill, C. V. 35, p. 272; Brown, G. C. 16b, p. 818; Logan, C. A. 25a, p. 428.)
°15	D	Cook and Green		3	47N	11W	MD	Active 1906; adits 125, 100, 75 ft. in wide structure. (Aubury, L. E. 08, p. 129; Stevens, H. J. 11, p. 1564.)
15A	D	Copper Creek (Blue Bell)	I. D. Turner, Redding, Calif. (1947)	31	16N	8E	H	(O'Brien, J. C. 47, p. 424.)
16	C?	Copper King claim	N. B. Wilson (1943)	20	40N	7W	MD	Copper mine (chalcopyrite), also pyrite, pyrrhotite, and quartz on dump; ore reported 10 ft. wide; worked 1932; two caved adits and a hold (shaft?). (O'Brien, J. C. 47, p. 424.)
		Copper Mountain: see Barnum Bros.						
17	D	Copper Queen		3	46N	7W	MD	Adit, 110 ft. (Brown, G. C. 16b, p. 818.)
18	D	Copper Queen Claim		27	46N	9W	MD	Adits, 300 ft. (Aubury, L. E. 05, p. 105; 08, p. 123.)
		Cummings: see McKeen						
		Dakin; see Gray Eagle						
		Davis: see Clear Creek						
19	C	Dewey	F. A. Wright, Oakland, Calif. (1942)	6	41N	6W	MD	Gold mine; also silver. (Averill, C. V. 35, p. 317.)
20	D	Dillon Creek		15	14N	4E	H	Copper mine; no work reported. (Averill, C. V. 35, p. 272; Logan, C. A. 25a, p. 428.)
21	D	Doolittle Creek		31	17N	7E	HM	Sulphides in open cut. (Aubury, L. E. 08, p. 132.)
°22	D	Driggs		18	40N	7W	MD	(Aubury, L. E. 08, p. 127.)
23	D	Eaton		15	40N	9W	MD	Copper minerals in garnet gangue, with quartz and calcite (contact deposit?). (Aubury, L. E. 08, p. 127.)

24	D	Efman and Boorse	Efman & Boorse, Happy Camp, Calif. (1934)	14	16N	7E	H	Copper mine; assessment work done 1925. (Averill, C. V. 35, p. 272; Logan, C. A. 25a, p. 428.)
25	C	Empire	J. W. Wright, Etna, Calif. (1944)	27, 34	41N	9W	MD	Gold-copper mine; open cut; stamp mill; 4-18 in. vein. (Averill, C. V. 31, p. 28; 35, p. 318.)
25A	D	Facey	Facey Bros., Etna, Calif. (1947)	23	41N	9W	MD	(O'Brien, J. C. 47, p. 425.)
°26	D	First National (Joe Creek)		33	48N	11W	MD	Adits develop mine to depth of 400 ft.; said to have large ore bodies. (Aubury, L. E. 08, p. 129; Weed, W. H. 18, p. 634.)
27	D	Fortuna		14	40N	8W	MD	Pyrrhotite in diorite; 40-ft. shaft. (Aubury, L. E. 05, p. 105; 08, p. 123.)
°28	D	Gilpin		4	17N	7E?	H	Strong gossan. (Aubury, L. E. 08, p. 132.)
29	C	Gold Ball	Gold Ball Mining Co., Sawyers Bar, Calif. (1938)	15	39N	11W	MD	Gold mine; also silver. (Averill, C. V. 35, p. 319.)
30	C	Gold Crown	Gold Crown Mining Co., Yreka, Calif. (1941)	11	45N	8W	MD	Gold mine; also silver, lead.
31	A	Gray Eagle (Dakin)	Gray Eagle Copper Co., c/o R. J. Hendricks, mgr., Happy Camp, Calif. (1945); Mason Valley mining Co., Nevada (1922)	4	17N	7E	H	Copper mine; flat-lying sulphide body, 5-20 ft.; low-grade disseminated ore in walls; little or no zinc. (Aubury, L. E. 08, p. 132; Averill C. V. 35, p. 272; Brown, G. C. 16b, p. 818; Laizure, C. McK 21, p. 531; Logan, C. A. 25a, p. 428; Maxson, J. H. 33, p. 145; Mining World 43, pp. 5-9; Neale, W. G. 27, p. 485; O'Brien, J. C. 43, p. 83; 47, pp. 425-427; Tucker, W. B. 23, p. 8; Weed, W. H. 14, p. 409; 18, p. 633; 20, p. 1066; 22, p. 1250.)
		Green: see Cook & Green						
32	D	Hathaway	F. R. Salter, Los Angeles, Calif. (1944)	11	40N	9W	MD	Gold mine; several hundred feet of workings on 18- to 24-in. fissure quartz vein. (Aubury, L. E. 08, p. 127; Averill, C. V. 35, p. 320.)
		Henry Wood: see Wood						
		Hetchell: see Barton						
33	D	Hidden Treasure		6	39N	8W	MD	One adit; vein said to be 8 ft. wide. (Aubury, L. E. 05, p. 105; 08, p. 124.)
		Houston: see Chalco Copper Co.						
34	C?	Hummer		18	40N	7W	MD	Said to contain nickel; shafts and open cuts developing irregular bodies in serpentine. (Aubury, L. E. 05, p. 104; 08, p. 123; Brown, G. C. 16b, p. 818.)
35	D	Huntley		12	40N	8W	MD	Adits, 100 ft.; shaft, 22 ft. (Aubury, L. E. 05, p. 105; 08, p. 124.)
36	D	Indian Creek		13	17N	7E	H	Wide bodies in slate; 475 ft. of adits. (Aubury, L. E. 05, p. 109.)

SISKIYOU COUNTY—Continued

Number	Class by production	Name of deposit	Name of owner or operator	Location: Sec.	T.	R.	B. & M.	Remarks and references
37	C?	Isabella	Isabella Copper Mining Co., Oakland, Calif. (1934)	34	41N	7W	MD	Copper mine; tetrahedrite in quartzite; adits, 330, 175 ft.; shaft, 45 ft., other workings; 80 acres patented; active 1911-15. (Averill, C. V. 31, p. 28; 35, p. 273; Laizure, C. McK 21, p. 532; Logan, C. A. 25a, p. 429; Weed, W. H. 20, p. 452.)
		Joe Creek: see First National						
38	D	Jones		27	48N	11W	MD	Copper mine (chalcopyrite, bornite); with quartz; vein, 5 ft.; adits, 230, 120 ft.; strong gossan. (Aubury, L. E. 08, p. 129.)
*39	B	Kennett Expl. Co.	Kennett Expl. Co., Ft. Jones, Calif. (1916)					Copper mine; produced 1915-16. (Yale, C. G. 17, p. 242.)
40	D	Klamath group		26	17N	7E	H	Gold mine.? Adit, 75 ft. (Aubury, L. E. 05, p. 109.)
41	D	Liberty Bond group	F. B. McCann, Happy Camp, Calif. (1934)	2, 3	16N	7E	H	Copper mine; ore in schist 1-1½% Cu. (Averill, C. V. 35, p. 273; Logan, C. A. 25a, p. 429.)
42	D	Little		12	46N	12W	MD	Adit 40 ft., on wide structure. (Brown, G. C. 16b, p. 818.)
43	D	Little Blue		34	17N	7E	H	Open cut. (Aubury, L. E. 08, p. 132.)
44	D	Lytle		20	40N	7E	MD	Adits, 300 ft. develop irregular bodies on serpentine contact. (Aubury, L. E. 05, p. 108; 08, p. 124.)
45	D	Malone	Churchill, Roseburg, et al., Yreka, Calif. (1934)	4	14N	8E	H	Copper mine. Adit, 160 ft.; specimen ore exhibited. (Averill, C. V. 35, p. 273; Logan, C. A. 25a, p. 429.)
45A	D	Mammon group	J. & A. Furlong, San Francisco, Calif. (1947)	14	41N	7W	MD	Gold mine. (O'Brien, J. C. 47, p. 443.)
46	C	McKeen (Oro Grande, Cummings, Shasta)	Oil, Inc., of California, San Francisco, Calif. (1940)	36	40N	9W	MD	Gold mine; with silver. (Averill, C. V. 35, p. 323.)
*47	C	Michigan	The Chalcopyrite Co., Gazelle, Calif. (1930)					Copper mine?; also silver.
48	D	Monarch		7	40N	7W	MD	Adits, 200 ft.; shafts, 20, 30 ft.; 240 acres patented. (Aubury, L. E. 05, p. 106; 08, p. 124; Brown, G. C. 16b, p. 819.)
		Mountain Laurel: see Stevens group						
		Nelson: see Bear Mountain						

*49	C	New	D. W. Bowers, Klamath River, Calif. (1942)					Gold mine; also silver.
50	C	New York	G. A. Milne, Ft. Jones, Calif. (1934)	2, 11	44N	9W	MD	Gold mine; also silver. (Averill, C. V. 35, p. 324.)
51	D	Nigger Creek group		13	46N	11W	MD	(Aubury, L. E. 05, p. 109; 08, p. 132.)
52	D	Oak Hollow		33	17N	8E	H	Small amount of copper; also pyrite; two adits. (Aubury, L. E. 08, p. 130.)
		Oro Grande: see McKeen						
53	D	Paradise group	W. F. Davis, Sacramento, Calif. (1935)	18	15N	7E	H	Gold mine. (Averill, C. V. 35, p. 325.)
54	D	Parker	G. J. Parker, Copper, Calif. (1934)	20, 21?	48N	11E	MD	Copper mine; adits, 200 ft. (Averill, C. V. 35, p. 273.)
55	D	Phillips		6	46N	12W	MD	Gossan traceable 1,500 ft.; adit, 110 ft., on wide structure. (Brown, G. C. 16b, p. 819.)
56	D	Plutus		12, 14	40N	8W	MD	Pyrrhotite with copper in serpentine and gabbro. (Aubury, L. E. 05, p. 105; 08, p. 123; Brown, G. C. 16b, p. 819.)
57	C	Polar Bear (Chalcopyrite)	Winters & Heath (1943)	12	40N	8W	MD	Copper mine (chalcopyrite, chalcocite), and pyrite—in serpentine; also zinc. Production said to be 200 tons 17% Cu in 1900; operated also in 1917. Adits, 120 ft.; shaft, 210 ft. (Aubury, L. E. 05, p. 106; 08, p. 124; Brown, G. C. 16b, p. 819; O'Brien, J. C. 43, p. 329; 47, p. 427.)
58	C	Preston Peak	E. S. Wallace, Los Angeles, Calif. (1942)	22	17N	5E	H	Copper mine; in 1942 very little Cu seen by examining engineer; work done in 1899; mine is inaccessible; adit 405 ft.; winze, 40 ft.; drift, 30 ft.; substantial irregular ore bodies in serpentine described; one said to be 8-40 ft.; up to 16% Cu, $2 Au. (Aubury, L. E. 05, p. 110; 08, p. 132; Brown, G. C. 16b, p. 819; Maxson, J. H. 33, pp. 139, 146; O'Brien, J. C. 47, pp. 427-428; Rothwell, R. P. 93, p. 161.)
59	D	Rader		17	40N	7W	MD	Pyrrhotite ore said to contain nickel. (Aubury, L. E. 05, p. 106; 08, p. 124.)
60	D	Rainbow group		24	40N	5W	MD	Wide gossan traceable one mile; 500-ft. adit cuts 6-ft. sulphide vein in serpentine. (Aubury, L. E. 05, p. 107; 08, p. 125; Brown, G. C. 16b, p. 819.)
61	D	Richie		7	39N	9W	MD	Copper mine; quartz vein 2-6 ft. (Crawford, J. J. 96, p. 64.)
62	D	Rothkoph		5, 6 7, 8	43N	8W	MD	Shafts and adits; 6-ft. vein in serpentine. (Aubury, L. E. 05, p. 106; 08, p. 125; Brown, G. C. 16b, p. 820.)
°63	D	St. Albans group		34	48N	11W	MD	Workings, 470 ft.; adjoins Blue Ledge. (Aubury, L. E. 08, p. 129.)

SISKIYOU COUNTY—Continued

Number	Class by production	Name of deposit	Name of owner or operator	Location				Remarks and references
				Sec.	T.	R.	B. & M.	
64	D	Schnider		12 18	40N 40N	8W 7W	MD MD	Open cuts. Similar to Polar Bear. (Aubury, L. E. 05, p. 107; 08, p. 125.)
		Shasta; see McKeen						
65	C	Shiner		7	46N	12W	MD	Adit, 80 ft., on wide vein in schist and limestone. (Brown, G. C. 16b, p. 820.)
66	D	Silver Mountain		20	40N	7W	MD	Adits with winzes and raises developing ore bodies in serpentine. (Aubury, L. E. 08, p. 126.)
67	D	Solomon		14	40N	8W	MD	Shaft 15 ft. (Aubury, L. E. 05, p. 105; 08, p. 123.)
68	C	Stevens group (Mountain Laurel)	Gold Ball Mining Co., Yreka, Calif. (1936)	15, 16	39N	11W	MD	Gold mine; also silver. (Averill, C. V. 35, p. 283; Logan, C. A. 25, p. 451.)
69	D	Sunshine	W. J. Brown, Happy Camp, Calif. (1934)	24 19	17N 17N	7E 8E	H H	Copper mine; adit, 130 ft., fails to reach vein. (Averill, C. V. 35, p. 273; Logan, C. A. 25a, p. 429.)
70	D	Tebbo		32	47N	9W	MD	Adit, 120 ft., in wide vein of ore. (Brown, G. C. 16b, p. 820.)
71	D	Ten Lakes		20	41N?	6W?	MD	Open cuts show good copper ore in complex veins in gabbro and granite. (Aubury, L. E. 08, p. 127; Stevens, H. J. 11, p. 1661.)
72	D	Thanksgiving		8	43N	9W	MD	Surface showing. (Aubury, L. E. 05, p. 106; 08, p. 125.)
73	D	Turner		7	40N	7W	MD	Showings. (Aubury, L. E. 05, p. 106; 08, p. 124.)
74	D	Unexpected		17	47N	8W	MD	Short adits; ore in serpentine. (Aubury, L. E. 05, p. 107; 08, p. 126.)
75	D	Welch		1	46N	12W	MD	Adits, 60, 30 ft.; strong gossan. (Brown, G. C. 16b, p. 820.)
76	C	White Bear	Maryland Mining Co., Sawyers Bar, Calif. (1936)	18, 19	39N	11W	MD	Gold mine, with silver. (Averill, C. V. 35, p. 329.)
77	D	Wood (Henry Wood)	Wood & Fehely (1934)	4	46N	12W	MD	Copper mine. (Averill, C. V. 35, p. 273; Logan, C. A. 25a, p. 429.)
78	D	Yellow Butte	Long Hill Mining Co., San Mateo, Calif. (1941)	25	43N	4W	MD	Copper mine (chalcopyrite) and molybdenite, on quartz veins in diorite; shaft, 300 ft. being retimbered 1935; caved 1944. (Aubury, L. E. 05, p. 107; 08, p. 126; Averill, C. V. 35, p. 273; Brown, G. C. 16b, p. 820; O'Brien, J. C. 47, p. 428.)

* Not shown on map because of lack of definite location.
° Not shown on map because of crowded condition.

SONOMA COUNTY

Number	Class by production	Name of deposit	Name of owner or operator	Location				Remarks and references
				Sec.	T.	R.	B. & M.	
1	D	Altamont		17	7N	10W	MD	Copper mine; no definite ore body; open-cut and shaft in serpentine. (Aubury, L. E. 05, p. 142; 08, p. 167; Bradley, W. W. 16, p. 319; Laizure, C. McK 26b, p. 333.)
2	C	Archer		30	8N	9W	MD	Copper mine; some rich float shipped; mineralization in sandstone and serpentine. Adits, 200, 200 ft. (Aubury, L. E. 05, p. 141; 08, p. 167; Bradley, W. W. 16, p. 319; Laizure, C. McK 26b, p. 333.)
*3	C	Baby Jack and Earl Clare			9N	10W	MD	Adit, 35 ft.; shaft 22 ft., in serpentine and limestone; some ore shipped in early days. (Aubury, L. E. 05, p. 142; 08, p. 167.)
4	D	Cornucopia (Squaw Creek, Healdsburg)		33, 34	12N	9W	MD	Copper mine, in extremely altered rock; adit, 315 ft.; shaft, 40 ft.; veins, 85, 10 ft. (Aubury, L. E. 05, p. 141; 08, p. 167; Boalich, E. S. 21f, p. 248; Laizure, C. McK 26b, p. 333.)
		Earl Clare: see Baby Jack and Earl Clare						
5	D	Gray Prospect		26	9N	12W	MD	(Bradley, W. W. 16, p. 320.)
6	D	Grizzly		5	9N	10W	MD	Adits, 100, 100 ft. (caved), on copper-stained croppings in sandstone and serpentine. (Aubury, L. E. 05, p. 142; 08, p. 167; Bradley, W. W. 16, p. 320.)
		Healdsburg: see Cornucopia						
		Squaw Creek: see Cornucopia						
	D	Wall Tract		30	8N	9W	MD	Rich float; 10-ft. shaft shows native mercury. (Aubury, L. E. 05, p. 141; 08, p. 166; Bradley, W. W. 16, p. 320.)
	D	Ward Tract		22	9N	10W	MD	Rich float but no vein in place. (Aubury, L. E. 05, p. 142; 08, p. 167; Bradley, W. W. 16, p. 320.)

* Not shown on map because of lack of definite location.

STANISLAUS COUNTY

Number	Class by production	Name of deposit	Name of owner or operator	Location Sec.	T.	R.	B. & M.	Remarks and references
*1	B	Selby & Co.	Selby & Co. (1902)		1N	11E	MD	Copper mine; recorded production may actually have come from a mine like Copper Crescent, just across the line in Calaveras County; produced in 1901-04. (Dolbear, S. H. 45, pp. B-122, 123.)

* Not shown on map because of lack of definite location.

TEHAMA COUNTY

Number	Class by production	Name of deposit	Name of owner or operator	Location Sec.	T.	R.	B. & M.	Remarks and references
		Basler: see White Bluff						
1	D	California and Massachusetts copper mine	McCampbell & Thomas, Red Bluff, Calif. (1927)	25	27N	9W	MD	Copper mine (chalcopyrite), and pyrite; low Cu content; several adits and drifts on a vein in schistose diabase; values said to be continuous over 250 ft. of vein. (Aubury, L. E. 08, p. 157; Averill, C. V. 28, p. 213; Martin, A. H. 08, p. 24; Tucker, W. B. 19b, p. 261; O'Brien, J. C. 46, p. 189.)
2	D	Elder Creek group		20 9, 10 15, 16	25N 24N	7W 7W	MD MD	"Indications." (Aubury, L. E. 05, p. 131; 08, p. 157; O'Brien, J. C. 46, p. 189.)
3	D	Halley		5	26N	9W	MD	(Aubury, L. E. 08, p. 158.)
	D	Kestner and Thompson	R. W. Alford	4	27N	7W	MD	Adits, 58, 27, 27 ft.; vein 4 ft. in serpentine. (Aubury, L. E. 05, p. 131; 08, p. 157.)
5	D	Perine	H. E. Nielson et al.	25	27N	8W	MD	(Aubury, L. E. 05, p. 131; 08, p. 157.)
6	D	Tom Head	California & Massachusetts Copper Mines Co. (1908)	31	27N	8W	MD	Open cut, 30-ft. tunnel; vein 5 ft. in greenstone containing carbonate ore. (O'Brien, J. C. 46, p. 189.)
7	D	Uncle Sam	H. E. Nielson et al., (1944)	25	27N	8W	MD	Greenstone-limestone contact; adits 300, 114, 60 ft.; drifts, 200 ft.; vein, 24 ft. (Aubury, L. E. 08, p. 158.)
8	D	Verde		24	27N	9W	MD	(Aubury, L. E. 08, p. 158.)
9	D	White Bluff (Basler)		4, 5 8, 9	25N	7W	MD	"Indications" of copper in chrome district. (Aubury, L. E. 08, p. 157; O'Brien, J. C. 46, p. 189.)

TRINITY COUNTY

Number	Class by production	Name of deposit	Name of owner or operator	Location				Remarks and references
				Sec.	T.	R.	B. & M.	
1	C	Bear Tooth Mining Co.		28	7N	7E	H	Gold mine; also arsenic; four parallel veins in gabbro and serpentine; adits, 125, 120, 110 ft. (Aubury, L. E. 08, p. 144; Averill, C. V. 41 pp. 25, 74; Brown, G. C. 16c, p. 878.)
		Betty Hebbard; see Craig						
*2	D	Big Buck			7N	7E	H	Shaft, 20 ft. (Aubury, L. E. 08, p. 114.)
*3	D	Birdie group			7N	7E	H	Quartz gangue; flat vein 1-2 ft. (Aubury, L. E. 08, p. 144.)
4	D	Black Palangus		36	1N	6E	H	Cut, 60 ft., on 20-ft. vein. (Aubury, L. E. 05, p. 123; 08, p. 148; Brown, G. C. 16c, p. 879.)
5	C	Brown Bear	E. E. Erich, French Gulch, Calif. (1942)	11, 12 13, 14 16, 24	33N	8W	MD	Gold mine; also copper. (Averill, C. V. 41, p. 75.)
*6	C	Carter	Brown Bear Mining & Devel. Co., Oakland, Calif. (1941)	Approx.	33N	8W	MD	Gold mine; also silver.
7	D	Cinderella		9	37N	7W	MD	Adits, 300 ft.; shaft, 50 ft., on 16-ft. vein. (Aubury, L. E. 05, p. 120; 08, p. 145; Brown, G. C. 16c, p. 879.)
8	D	Cold Creek		20?	2N	7E	H	Open cut; low-grade ore in serpentine. (Aubury, L. E. 05, p. 118; 08, p. 142.)
9	D	Copper Button		36	37N	7W	MD	Oxidized copper ore in serpentine; short adits, open cuts. (Aubury, L. E. 05, p. 120; 08, p. 145; Brown, G. C. 16c, p. 879.)
10	C	Copper Jack	Conroy, Brewer, & Taylor, Castella, Calif. (1929)	2	37N	6W	MD	Copper mine; also silver.
11	D	Copper Queen		10, 11	1S	6E	H	Gossan croppings; 40-ft. adit. (Aubury, L. E. 05, p. 124; 08, p. 146; Brown, G. C. 16c, p. 879.)
12	D	Copper Queen group		16	37N	7W	MD	Gold mine, with copper (secondary chalcocite); in metabasaltic dike in serpentine and meta-andesite. (Aubury, L. E. 05, p. 120; 08, p. 145; Brown, G. C. 16c, p. 879; MacDonald, D. F. 13, pp. 17, 29.)
13	C	Craig (Mason & Thayer, Betty Hebbard)	J. B. & F. J. McCauley, San Francisco, Calif. (1941)	4, 5 33	34N 35N	10W 10W	MD MD	Gold mine; also silver. (Averill, C. V. 41, p. 77.)
14	D	Crown Point		18	37N	7W	MD	Short adit, open cuts. (Aubury, L. E. 05, p. 122; 08, p. 145; Brown, G. C. 16c, p. 879.)

TRINITY COUNTY—Continued

Number	Class by production	Name of deposit	Name of owner or operator	Location Sec.	T.	R.	B. & M.	Remarks and references
15	C	Enterprise (including Yellowstone)	Chiksan Oil Co., Fullerton, Calif. (1941)	29, 32	35N	11W	MD	Gold mine; also silver, lead. (Averill, C. V. 41, p. 77.)
16	D	Eureka group		17, 18	37N	7W	MD	Low-grade siliceous ore; 50-ft. adit. (Aubury, L. E. 05, p. 122; 08, p. 145; Brown, G. C. 16c, p. 879.)
*17	D	Fortuna group			1S	6E	H	Conspicuous gossan. (Aubury, L. E. 02, p. 122; 08, p. 146; Brown, G. C. 16c, p. 879.)
*18	D	Granite group			8N	7E	H	In serpentine and slate. (Aubury, L. E. 05, p. 120; 08, p. 143; Brown, G. C. 16c, p. 879.)
19	C	Headlight	Trinity Gold Mining & Red. Co. (1912)	21	37N	7W	MD	Gold mine. (MacDonald, D. F. 13, pp. 17, 21.)
20	D	Iron Mountain		27	1S	6E	H	Open cuts; low-grade oxidized ore. (Aubury, L. E. 05, p. 124; 08, p. 146.)
21	A	Island Mountain	E. R. Leach, 214 Hillside Ave., Piedmont, Calif. (1943)	9, 10 15	5S	6E	H	Copper mine, with gold, silver, iron. Fe-Cu sulphide body; said to lie within a "shale-sandstone-serpentine complex;" produced 1915-19, 1922-30. (Aubury, L. E. 05, pp. 124-126; Averill, C. V. 41, pp. 23-24, 81; Brown, G. C. 16e, p. 881; Johnston, W. D. Jr. 35, p. 251; Lang, H. 99, p. 5; Logan, C. A. 26, p. 14; Neale, W. G. 27, p. 492; Rand, L. H. 31, p. 588; Weed, W. H. 14, p. 483; 16, p. 483.)
22	D	Jackson and Carter		29	31N	10W	MD	Sulphide zone, 10-12 ft.; shaft, 40 ft. (Aubury, L. E. 05, p. 122; 08, p. 146; Brown, G. C. 16e, p. 881.)
23	C	June	G. W. Leas, Lewiston, Calif. (1940)	2	33N	9W	MD	Gold mine, with silver.
24	D	Lambert		9	1S	8E	H	Sulphide in diorite; short adits, shaft. (Aubury, L. E. 05, p. 119; 08, p. 142.)
25	C	Last Chance (Montezuma)	G. R. Miller, Lewiston, Calif. (1941)	12, 13	33N	8W	MD	Gold mine; also silver. (Averill, C. V. 41, p. 82.)
26	D	Last Chance		31	7N	7E	H	Large gossan eroppings; adit. (Aubury, L. E. 08, p. 145.)
27	D	Le Blanc		17	37N	7W	MD	(Aubury, L. E. 08, p. 146.)
		Liberty: see Poeth						
28	D	Lone Pine		19	1N	8E	H	In diorite. Short adits, shaft. (Aubury, L. E. 05, p. 119; 08, p. 142.)

29	D	Lorenze		27, 28, 34	34N	11W	MD	Native copper in limestone; patented. (Miller, W. P. 90, p. 716.)
30	D	Maddox		28	2N	7E	H	Small ore bodies in serpentine and diorite. (Aubury, L. E. 05, p. 119; 08, p. 142.)
31	D	Maitland		14	38N	7W	MD	(Aubury, L. E. 05, p. 122; 08, p. 146.)
		Mason & Thayer: see Craig						
		Modoc Gold: see Wagner						
		Montezuma: see Last Chance						
32	D	Murphy		36	1N	7E	H	Dike in serpentine; adit, 100 ft.; three shafts. (Aubury, L. E. 05, p. 119; 08, p. 143; Brown, G. C. 16c, p. 881.)
33	D	Nonpareil		5	36N	12W	MD	Gossan; adit, 35 ft.; cuts; 1-14 ft. vein, on slate-diorite contact. (Aubury, L. E. 05, p. 120; 08, p. 143; Brown, G. C. 16c, p. 881; Crawford, J. J. 96, p. 64.)
*34	D	Pattie			1S	7E	H	(Aubury, L. E. 05, p. 119; 08, p. 143.)
35	C	Paymaster	P. X. Johnson estate, Redding, Calif. (1941)	2	33N	8W	MD	Gold mine; also silver, lead. (Averill, C. V. 41, p. 85.)
36	C	Poeth (Liberty)	Liberty Mines Co. (1941)	4	37N	8W	MD	Gold mine? also silver, lead; "sulphides and tellurides."
37	C	Quimby	Larsen Bros., Sawyers Bar, Calif. (1941)	22	7N	7E	H	Gold mine, with copper, arsenic; small gold mill 1915; adits, 400, 125 ft.; drift, 150 ft.; raise, 122 ft.; vein, 4 ft. (Aubury, L. E. 08, p. 144; Averill, C. V. 41, p. 85; Brown, G. C. 16c, pp. 681, 896.)
*38	D	Shoemaker			37N	6W	MD	(Aubury, L. E. 05, p. 122; 08, p. 146.)
39	C	Starvation	F. L. Lewis, Lewiston, Calif. (1941)	11	33N	8W	MD	Gold mine, also silver. (Averill, C. V. 41, p. 87.)
40	C	Tangle Blue	Grand National Mining Co., Callahan, Calif. (1937)	30 25	39N 39N	8W 9W	MD MD	Gold mine; also silver.
		Trinity Bonanza King: see Trinity County mine						
41	C	Trinity County (Trinity Bonanza King)	United Trinity Mines, San Francisco, Calif. (1941)	14, 15	37N	7W	MD	Gold mine; in early days 2½ tons high grade were shipped; adit, 70 ft.; shaft, 12 ft. (Averill, C. V. 41, p. 88; Miller, W. P. 90, p. 716.)
42	D	Vine Oak		35 2	1N 1S	7E 7E	H H	Small sulphide bodies in diorite. (Aubury, L. E. 05, p. 119; 08, p. 143; Brown, G. C. 16c, p. 882.)
43	C	Wagner (Modoc Gold)	Wagner Mining & Milling Co., Carrville, Calif. (1941)	3 34	37N 38N	8W 8W	MD MD	Gold mine; also silver. (Averill, C. V. 41, p. 89.)
		Yellowstone: see Enterprise						

* Not shown on map because of lack of definite location.

TULARE COUNTY

Number	Class by production	Name of deposit	Name of owner or operator	Location Sec.	T.	R.	B. & M.	Remarks and references
1	D	Annie Fox	Interstate Industrial & Transportation Co., Tulare, Calif. (1929)	14, 23	17S	31E	MD	Copper mine (chalcopyrite); mineralized zone on uptilted slate-limestone contact. (Franke, H. A. 30a, p. 434; Tucker, W. B. 19d, p. 908.)
2	D	Barber No. 1		14	23S	28E	MD	(Aubury, L. E. 05, p. 236; 08, p. 290.)
3	D	Barber No. 2		19	21S	29E	MD	Gossan in diabase and amphibolite schist. (Aubury, L. E. 05, p. 236; 08, p. 290.)
4	D	Barber-Witt		30	19S	31E	MD	Adit, 50 ft., on granodiorite-porphyry contact. (Tucker, W. B. 19d, p. 908.)
*5	D	Blue Crystal			20S	27E	MD	Adit, 75 ft., on narrow vein in serpentine. (Aubury, L. E. 08, p. 293.)
6	C	Cedar Hill	Grantzich & Powell (1943)	29	19S	31E	MD	Lead-silver mine. (Franke, H. A. 30a, p. 467.)
7	D	Copper Mountain		34, 35	14S	31E	MD	Active 1900; adit, 50 ft.; shaft, 18 ft. (Aubury, L. E. 05, p. 236; 08, p. 292.)
8	D	Copper Queen		23	15S	31E	MD	Granite-slate contact; above snowline. (Crawford, J. J. 94, p. 70.)
9	D	Dewey		32	19S	31E	MD	(Aubury, L. E. 05, p. 236; 08, p. 292.)
*10	D	Gill			20S	27E	MD	Workings, 90 ft.; on 2-ft. vein. (Aubury, L. E. 08, p. 293.)
11	D	Gram	P. Gram (1929)	3	20S	27E	MD	Copper mine (chalcopyrite); shaft, 75 ft. (Franke, H. A. 30a, pp. 434-435.)
12	C	Grider		31	19S	31E	MD	Test lots shipped. (Aubury, L. E. 05, p. 234; 08, p. 290.)
13	D	Hamilton		33	18S	27E	MD	Shaft, 110 ft., on shear zone, in mica schist. NW. strike, 75° NE. dip. (Tucker, W. B. 19d, p. 908.)
14	D	Hart group	W. H. Hart, Badger, Calif. (1929)	2	15S	28E	MD	Copper (bornite, chalcopyrite, malachite, azurite); several mineralized zones on granite-limestone, contact. (Franke, H. A. 30a, p. 435.)
15	D	Iron Capping		16	20S	31E	MD	
*16	D	Keller			19S	31E	MD	(Aubury, L. E. 05, p. 236; 08, p. 290.)
17	D	Kirkland		2	15S	28E	MD	(Laizure, C. McK 23, p. 523.)

18	D	Lady Franklin	J. J. Crabtree, Mineral King, Calif. (1929)	25	17S	31E	MD	Lead-zinc mine (galena, sphalerite); also copper (chalcopyrite) and arseno-pyrite, in thin-bedded limestone. (Franke, H. A. 30a, p. 468.)
19	D	Lion's Nest		14	17S	31E	MD	Adit, 400 ft., fell short of mineralized zone on slate-limestone contact. (Tucker, W. B. 19d, p. 909.)
20	D	Oakland		25	15S	31E	MD	Shaft, 80 ft.; adits, 70, 30 ft.; on 80-ft zone on granite-limestone contact. (Tucker, W. B. 19d, p. 909.)
21	D	Mankins		23	19S	28E	MD	(Crawford, J. J. 94, p. 70.)
22	D	Page		17	18S	26E	MD	Vein, 4 ft. (Crawford, J. J. 96, p. 64; Tucker, W. B. 19d, p. 909.)
23	C	Powell	A. M. Powell, Springville, Calif. (1930)	30, 32	19S	31E	MD	Zinc (sphalerite), copper (chalcopyrite), lead (galena); with pyrite, arsenopyrite, pyrrhotite; altitude, 5,200 ft.; adits, 170, 60, 50, 30, 20 ft.; shafts, 20, 20 ft.; on 15-20 ft. complex ore bodies, at granite-limestone-quartzite contact; Cu, Pb, Zn, Fe sulphides in epidote-amphibole gangue; excerpts from engineer's report (see Franke 30a) give the deposit considerable promise; apparently inaccessible. (Aubury, L. E. 05, p. 234; 08, p. 290; Franke, H. A. 30a, pp. 435-436; Tucker, W. B. 19d, pp. 909-910.)
24	D	Round Valley Copper		10	20S	27E	MD	Granite-serpentine contact; active 1916. (Tucker, W. B. 19d, p. 910.)

* Not shown on map because of lack of definite location.

TUOLUMNE COUNTY

Number	Class by production	Name of deposit	Name of owner or operator	Location				Remarks and references
				Sec.	T.	R.	B. & M.	
1	D	Adams		16	3S	15E	MD	(Aubury, L. E. 05, p. 202; 08, p. 249.)
2	C	Atlas	B. Stoner, Sonora, Calif. (1938)	29	2N	14E	MD	Gold mine; also silver. (Logan, C. A. 35, p. 158; Julihn, C. E. 40, pp. 66-67.)
		Belmont-Shawmut: see Eagle Shawmut						
		Bonne Terre: see Mitchell						
3	C?	Chinese Camp	Mrs. D. E. Stratton, Chinese Camp, Calif. (1936)	9	1S	14E	MD	In town of Chinese Camp; shaft, about 100 ft. (Aubury, L. E. 05, p. 201; 08, p. 248.)
4	C	Contention	Kappel Mining Co., Sonora, Calif. (1936)	16, 17	3N	15E	MD	Gold mine; also silver. (Logan, C. A. 28, p. 25.)
5	C	Densmore	Densmore Gold Mines, Inc., Columbia, Calif. (1941)	3, 4	2N?	16E	MD	Gold mine; also silver.
6	C	Donahue Ranch		23	2S	14E	MD	Copper mine; adit, 1,000 ft.; some production about 1907. (Aubury, L. E. 05, p. 202; 08, p. 249; Lang, H. 07, p. 1010; Logan, C. A. 28, p. 7.)
7	C	Draper (Whitto)	Draper Vein Syndicate, San Francisco, Calif. (1935)	36	2N	15E	MD	Gold mine; also silver, lead. (Logan, C. A. 28, p. 40; Tucker, W. B 16b, p. 144; Julihn, C. E. 40, p. 56.)
8	C	Duleeke 1-2-3 (Duleek)	Duleeke, Inc., Los Angeles, Calif. (1937)	2	1S	16E	MD	Gold mine; also silver. (Logan, C. A. 28, p. 26.)
9	C	Eagle-Shawmut (Belmont-Shawmut)	Miller & Clemson, Los Angeles, Calif. (1944)	1, 2 11, 12	1S	14E	MD	Gold mine; also silver; produced 1941-44. (Logan, C. A. 35, p. 162; Julihn, C. E. 40, pp. 43-49.)
10	C	Erin-Go-Bragh	Del Gold Corp., Chicago, Ill. (1940)	27	1N	14E	MD	Gold mine; also silver, lead. (Logan, C. A. 28, p. 27.)
		Golden City: see Olsen						
		Greenstone: see Mann						
*11	C	Hard to Find	McPherson & Nead, Sonora, Calif. (1935)	Approx.	2N	14E	MD	Gold mine; also silver.
12	C	Hazel Dell	Hayes & Symons, Inc., Sonora, Calif. (1937)	35, 36	3N	15E	MD	Gold mine; also silver, lead.

*13	C	Henning	I. B. Henning, River Forest, Ill. (1940)	Approx.	2N	15E	MD	Gold mine; also silver.
14	C	Heslep	Gold Diggers Syndicate, Jamestown, Calif. (1938)	22	1N	14E	MD	Gold mine; also silver. (Julihn, C. E. 40, pp. 36-41; Logan, C. A. 28, p. 29; 35, p. 166.)
15	C	Hitchcock	Sonora Abstract & Title Co., Sonora, Calif. (1936)	22	1N	14E	MD	Gold mine; also silver, lead. (Julihn, C. E. 40, pp. 36-41; Logan, C. A. 28, p. 29.)
16	D	Kahl Ranch		6, 7	1N	14E	MD	Copper mine; some chrome ore shipped. (Aubury, L. E. 05, p. 201; 08, p. 248; Logan, C. A. 28, p. 7.)
17	C	La Guria	La Guria Gold Mining Co., Los Angeles, Calif. (1941)	21	1S	16E	MD	Gold mine; with silver, lead. (Logan, C. A. 28, p. 31.)
		Mackey Ranch: see Ohio Diggings						
18	C	Mann (Greenstone)	D. L. Mann, Quartz, Calif. (1917)	27, 28	1N	14E	MD	Copper mine; also gold? Small production; shaft, 90 ft. (Logan, C. A. 28, p. 7; Tucker, W. B. 16b, p. 135.)
19	D	Mariano Ranch		4, 5 8, 9	1S	14E	MD	Copper mine. (Logan, C. A. 28, p. 7.)
*20	C	Mildred Lloyd	J. B. Simdar, San Francisco, Calif. (1941)	Approx.	2N	15E	MD	Gold mine; also silver, lead.
21	D	Mitchell (Bonne Terre)	Locke Robinson, Sonora, Calif. (1916)	30	2S	14E	MD	Gold, silver, zinc; shaft, 125 ft. (Logan, C. A. 28, p. 7; Tucker, W. B. 16b, p. 135.)
22	D	Moccasin Creek		19, 20 28, 29	1S	15E	MD	(Aubury, L. E. 05, pp. 201-202; 08, p. 249.)
23	B?	Oak Hill (now includes Olsen)	c/o W. M. Collins, Mills Bldg., San Francisco, Calif.	32	2S	14E	MD	Copper mine; apparently main production from chalcocite zone; low-grade at depth; C-production during 1929-30; possibly B, including 1901-02, 1907. (Aubury, L. E. 05, p. 202; 08, pp. 250-251; Julihn, C. E. 40, pp. 85-86; Lang, H. 07, p. 1010; Logan, C. A. 28, p. 7; Tucker, W. B. 16b, p. 135.)
24	C	Oak Mesa	A. G. Keating, Los Angeles, Calif. (1936)	22	3S	15E	MD	Copper mine; also silver.
25	C	Ohio Diggings (Mackey Ranch)	Peter Mackey, Jamestown, Calif. (1916)	21, 28	1N	14E	MD	Copper mine; produced in 1915. (Aubury, L. E. 05, p. 201; 08, p. 248; Logan, C. A. 28, p. 7; Tucker, W. B. 16b, p. 135.)
26	C	Olsen (Golden City) (now part of Oak Hill)		31, 32	2S	14E	MD	Production mainly in gold; disseminated sulphides. (Aubury, L. E. 05, p. 201; 08, p. 248; Lang, H. 07, pp. 964, 966.)
27	C	Patterson	J. F. Kingston, Sonora, Calif. (1930)	29	2N	14E	MD	Gold mine; also silver. (Logan, C. A. 35, p. 170.)

TUOLUMNE COUNTY—Continued

Number	Class by production	Name of deposit	Name of owner or operator	Location Sec.	T.	R.	B. & M.	Remarks and references
*28	C	Royal	E. O. Heinrich, Rawhide, Calif. (1935)	Approx.	2N	14E	MD	Gold mine; also silver.
29	B	Salambo (Washington)		30, 31, 32	2S	15E	MD	Copper mine; active about 1907; town of 400 supported by mine in early days. (Aubury, L. E. 05, p. 202; 08, pp. 249, 251; Lang, H. 07, p. 1010; Logan, C. A. 28, p. 7; Tucker, W. B. 16b, p. 135; Julihn, C. E. 40, p. 86.)
30	C	Shanghai	Triangle Mining Co., Columbia, Calif. (1938)	6, 7	2N	15E	MD	Gold mine; also silver. (Logan, C. A. 28, p. 38.)
31	D	Shell Ranch		17	1N	14E	MD	(Aubury, L. E. 05, p. 201; 08, p. 248.)
32	C	Star	Hayes Co. (1940)	23, 24	3N	15E	MD	Gold; also silver. (Logan, C. A. 28, p. 38.)
33	C	Tex	L. A. Wertheim, Stanislaus, Calif. (1936)	5	3N	15E	MD	Gold mine; also silver.
		Washington: see Salambo						
		Whitto: see Draper						

* Not shown on map because of lack of definite location.

VENTURA COUNTY

Number	Class by production	Name of deposit	Name of owner or operator	Location Sec.	T.	R.	B. & M.	Remarks and references
1	C?	Ventura Mine	Mrs. E. W. Gard, Los Angeles, Calif. (1931)	5?	1N	18W	SB	Nickel-copper mine; said to average more than 1% Ni; gabbro dike mineralized with millerite, pentlandite, pyrrhotite, and chalcopyrite; shaft, 100 ft.; crosscuts, 135, 90 ft.; adit, 200 ft.; on gabbro intrusive, 500 x 800 ft., showing nickel sulphides with traces of copper. (Tucker, W. B. 32, pp. 257-258.)

YUBA COUNTY

Number	Class by production	Name of deposit	Name of owner or operator	Location				Remarks and references
				Sec.	T.	R.	B. & M.	
1	D	Ayer		35	16N	5E	MD	Quartz vein in slate, 3 ft., strike N. 40° W.; shaft, 30 ft.; (Waring, C. A. 19b, pp. 424-425.)
2	C	Brady Ranch (Old Red Ledge)		1	15N	5E	MD	Old shaft said to have been exploited in early days. (Aubury, L. E. 05, p. 172; 08, p. 205.)
3	D?	Copper Crescent		19	14N	6E	MD	Copper mine.
4	D	Dempsey Ranch		3	15N	6E	MD	Zone showing wide gossan croppings; 100-ft. adit; seems worthy of investigation; the deposit has never been properly explored. (Aubury, L. E. 05, p. 172; 08, p. 205.)
5	C	Eagle Delle	Assoc. Miners, Strawberry Valley, Calif. (1935)	20, 21	20N	8E	MD	Gold mine; also silver.
6	C	Horse Shoe	Horseshoe Co., Challenge, Calif. (1933)	20	19N	7E	MD	Gold mine; also silver, lead.
		Old Red Ledge: see Brady Ranch						
*7	C	Paul Copper	S. F. Paul, Marysville, Calif. (1918)	Approx.	16N	6E	MD	Copper mine; also gold, silver.

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